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Central Provinces Forest Conference, 1908

PROCEEDINGS

OF A

FOREST CONFERENCE

HELD AT

NAGPUR

23rd November to 1st December 1908

00109041

COMPILED BY

C. G. ROGERS, Esq., F.C.H., F.L.S.

Conservator of Forests, Berar Circle, Central Provinces

Nagpur

PRINTED AT THE GOVERNMENT PRESS

1910

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INTRODUCTION.

The first Conference of Forest Officers of the Central Provinces was held with the sanction and cordial co-operation of the Honourable Mr. Craddock, Chief Commissioner of the Central Provinces, at Nagpur from the 23rd November to the 1st December 1908. Invitations to attend the Conference were sent to Forest Officers of other Provinces ; to the principal Native States ; and Officers of other Departments in the Central Provinces who were interested in Forestry. Three Forest officers from the Bombay Presidency (Messrs. Fisher, Newman and Maitland-Kirwan), two from the Punjab (Messrs. Blascheck and Jerram), Mr. A. M. Caccia, representing the Imperial Forest Research Institute, and four Forest officers from Native States (Mr. Narsingh Rao, *Bhopal*, Mr. Luchman Das, *Jodhpur*, Mr. Ganesh Lal, *Alwar*, and Mr. G. A. Rooke, *Bastar*), attended the Conference and took part in the discussions which followed.

The Chief Commissioner honoured the Conference with his presence at the last meeting, when the resolutions drawn up during its session were read and passed, and took part in the discussion which ensued. His keen interest in the proceedings of the Conference and the generous support extended by him to the organisers, which did so much to make the Conference the success it undoubtedly was, were much appreciated by the members of the Conference. With the exception of Mr. P. Hemingway, I. C. S., Director of Agriculture, who attended the discussion on Mr. Best's paper on the effect of grazing on forest growth in the Bhandara district, no officers of other Departments attended any of the meetings.

Owing to the unavoidable absence of Mr. A. M. Reuther, Chief Conservator of Forests, Central Provinces, and of Mr. A. F. Gradon, Conservator of Forests, Northern Circle, the senior officer present, Mr. C. G. Rogers, Conservator of Forests, Berar Circle, presided. Profiting by the experience of the Punjab Forest Conference held at Lahore in January 1908, the papers to be read at the Conference were printed and circulated to all members beforehand, thus allowing members to study them and take an active part in the discussions which followed. Unfortunately some papers were received too late to allow of members making themselves familiar with their contents before the papers themselves were discussed. The Conference met once a day for three hours, with the result that members' interest in the proceedings was well maintained and much useful work was got through. The papers were taken as read and discussion of the points raised in the paper was invited. As this resulted in rather desultory talking, at the later meetings of the Conference, the author of the paper briefly summarized its contents, and drew attention to those points on which he invited discussion or asked for information. This procedure had the desired effect of keeping the discussion in well defined channels and of allowing resolutions being framed expressing the views of the members of the Conference on the subjects brought under discussion.

The advantage of the attendance of Forest officers from other Provinces was strongly felt throughout the discussions and the information communicated by them, especially with regard to the vastly different effect of the same treatment on the same species of trees, or types of forest, was most valuable and instructive. It clearly showed the very marked effect of the factors of the locality on the behaviour of trees and crops subjected to the same treatment ; how necessary a thorough knowledge of local conditions is to the prescription of the sylvicultural rules ; and how dangerous it is to generalize from one's own personal experience.

The resolutions passed by the Conference are given at the end of the record of the proceedings on each paper. A reference to them will show how vast is the amount of information required on most of the subjects brought up for discussion, and points to the inadvisability of holding another Conference next year. It will take some time to get together the information required to proceed further, and until this information has been obtained and put into a form in which it can be considered by the members, the holding of another Conference cannot lead to much direct good. It is proposed to ask members to take up definite lines of work and to ask them to select one of their number to collate the information recorded. When this has been done another Conference will be most useful in furthering the progress of scientific Forestry in the Central Provinces.

Unfortunately the shorthand type-writer engaged for the Conference failed to put in an appearance, and a substitute obtained locally, at the last moment, signally failed to take down the discussions in an intelligible form. The record is therefore regretably incomplete. The papers have been carefully corrected by their several authors and an attempt has been made to recall the principal points of the discussions which ensued. The plates and maps which illustrate the papers have been prepared by the Survey of India, and our grateful acknowledgments are due to the Superintendent, Map Publication Office, Calcutta, for the very careful way in which the drawings and photographs have been reproduced.

The programme of the sittings of the Conference and a list of the Forest officers who attended them are appended.

Programme of the Nagpur Forest Conference.

23rd November, 11 A. M. *to* 2 P. M.—Mr. Caccia's paper on the standardization of the methods of collection of statistical data relating to the principal Indian species (begun).

24th November, 8 A. M. *to* 11 A. M.—Mr. Lowrie's paper on the propagation and collection of lac in the Raipur district, Central Provinces.

25th November, 11 A. M. *to* 2 P. M.—Mr. McCrie's paper on the mixed teak forests of the Saugor Division, Northern Circle, Central Provinces, and their treatment.

26th November, 8 A. M. *to* 11 A. M.—Mr. Donald's paper on the Allapilli Monorail Tramway.

27th November, 11 A. M. *to* 2 P. M.—The Hon'ble J. Best's paper on the influence of, or protection from, cattle-grazing in the Bhandara Division, Southern Circle, Central Provinces.

28th November, 8 A. M. *to* 11 A. M.—Mr. Caccia's paper on the standardization of the methods of collection of statistical data relating to the principal Indian species (finished).

30th November, 8 A. M. *to* 11 A. M.—Mr. Witt's paper on the germination and development of *Hardwickia binata* (Anjan) and Mr. Shrinivasalu Navadu's paper on the distribution and cultivation of *Acacia arabica* (Babul) in Berar.

1st December, 8 A. M. *to* 11 A. M.—Consideration of the resolutions drawn up at the several Conferences and the discussion of arrangements for the next Forest Conference.

Names of Forest Officers who attended the Conference.

Officers of the Central Provinces.

Southern Circle.	*Northern Circle.*	*Berar Circle.*
A. V. Monro.	C. Somers-Smith.	C. G. Rogers, *President.*
A. C. Lowrie.	C. M. McCrie.	H. E. Bartlett.
A. St. V. Beechy.	A. P. Percival.	D. O. Witt.
G. M. Townshend.	P. S. Corbould.	C. A. Von B. Malcolm.
J. Donald.	V. H. Forbes.	C. F. Bell.
Hon. J. W. Best.	S. G. Paranjpe.	C. E. C. Cox.
R. B. Mansukh Rai.	A. L. Chatterjee.	S. Shrinivasalu Naidu.
	P. Shankarnath.	Pandurang Narayan.

Officers of other Provinces.

A. M. F. Caccia, *Imperial Research Institute.*

W. Fisher, *Bombay.*
H. L. Newman, *Bombay.*
J. D. Maitland-Kirwan, *Bombay.*
Laxman Dass, *Jodhpur.*
A. D. Blascheck, *Punjab.*
M. R. K. Jerram, *Punjab.*
Narsingh Rao, *Bhopal.*
Ganeshi Lal, *Alwar.*

E. A. Rooke, *Bastar.*

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(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTIONS ADOPTED.

PAPER

ON

THE COLLECTION OF STATISTICAL DATA RELATING TO THE PRINCIPAL INDIAN SPECIES

BY

A. M. CACCIA, Esq., M.V.O.,

Deputy Conservator of Forests, Imperial Superintendent of Working-Plans.

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THE COLLECTION OF STATISTICAL DATA RELATING TO THE PRINCIPAL INDIAN SPECIES.

PART I.—METHOD OF PROCEDURE.

CHAPTER I.—THE EXAMINATION AND MEASUREMENT OF SINGLE FELLED TREES, AND THE STUMPS OF FELLED TREES.

SECTION 1—RING COUNTINGS.

Object of Experiment.

The object of ring countings is to determine the rate of mean annual girth increment in each girth class of single trees, which have grown up under given conditions; that is, the number of years taken to grow from one given girth class to one higher; and consequently the number of years (rotation) required to produce, under given conditions, trees of given girths. It is evident that such data can only be obtained from species showing distinct (true) annual rings.

Selection of Stumps.

In the case of all forests under systematic working, ring countings should be confined to the year's felling area. Wherever fellings are being carried out in accordance with the provisions of sanctioned working-plans, the rings on the stumps of a certain number of the felled trees should be counted. The ring countings will therefore usually bear on trees of the higher girth classes. But ring countings should not be confined to these; stumps of trees of all girths, when available, will be taken into consideration. The upper section of the stump should show a clean cut, which may, if necessary, be made clear by the use of an adze.

Only the stumps of trees of normal growth should have their rings counted; and not those whose growth has been stunted by suppression, or for other reasons.

Similarly, ring countings will not be made on stumps with very eccentric growth.

The aspect, the soil, and the nature of growth surrounding each stump will be carefully recorded in the remarks column of the prescribed register.

Ring Countings.

Ring countings will be made along a mean radius: the mean radius being calculated from the mean diameter, which will in its turn be the mean of the longest and shortest diameter.

The number of rings along each inch of the mean radius will be carefully counted from centre to periphery and recorded in the prescribed form, Form A.*

The thickness of the sapwood and bark will also be recorded along the mean radius.

Register of Countings.

A register of ring countings in prescribed Form A* will be maintained in the Divisional office and at the Imperial Forest Research Institute. Copies of all entries made in the Divisional register will be forwarded annually to the Imperial Superintendent of Forest Working-plans at the Research Institute for record.

The data so collected will be collated and published at the Research Institute from time to time.

Rules for the carrying out of Ring Countings.

Rule 1.—Only stumps of sound normally grown trees will be selected for ring countings.

Rule 2.—As a rule ring countings will be made of a certain number of stumps situated in the felling area of the year.

Rule 3.—The rings will be counted on a mean radius inch by inch from centre to periphery consecutively, as given in the sample form.

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* Appendix A at end.

The mean radius will be obtained by taking the mean of the longest and shortest diameters without bark and dividing this by two, and laying this radius out on the stump. The wood along the mean radius will be smoothed with an adze or other instrument.

Rule 4.—The thickness of sapwood and bark along the mean radius will be recorded in inches and decimals of an inch.

Rule 5.—A steel tape will be used for recording these statistics.

Rule 6.—The rainfall, nature of the soil, aspect, elevation, surrounding tree growth (*e. g.*, height corresponding to given girth, &c.) in the vicinity of the stump will be recorded in the remarks column of the prescribed register.

Rule 7.—A register in prescribed form* will be maintained in the Divisional office, and at the Imperial Forest Research Institute. Copies of all entries made in the Divisional register will be forwarded annually to the Imperial Superintendent of Forest Working-plans at the Research Institute for record.

The data so collected will be collated and published at the Research Institute from time to time.

SECTION 2—THE PREPARATION OF VOLUME TABLES.

OBJECT OF EXPERIMENT.

Volume tables show the average contents of standing trees of different sizes: they are used to estimate the yield of wood and timber for given localities; but they are intended only for estimating a large number of trees. The data so collected may also be used for calculating the age at which the mean annual volume increment of single trees culminates.

Volume tables may be prepared to show the total volume of trees of different sizes; or the volume of timber and small wood separately for the whole tree or for the stem only; or the volume of merchantable timber; or the outturn which may be expected in logs or planks of a given size; or other grades of timber. In each case it is essential that an exact definition of "*timber*," "*small wood*" and "*graded timber*" be given.

As to the exact form of volume table which should be prescribed for India opinions will vary considerably, since on the one hand no scientific definition of timber, as compared with small wood, has yet been accepted in India, and on the other hand no regular well-established markets exist which would naturally prescribe the size of the different grades of timber.

COLLECTION OF DATA.

For the present it is suggested that data be collected showing for each tree:—

(*a*) The girth at breast height (4′ 6″ from ground).
(*b*) The number of rings at base.
(*c*) The total height.
(*d*) The volume of stem timber (*i. e.*, timber over 24″ in girth at the small end).
(*e*) The outturn in scantlings (*e. g.*, M. G. sleepers, B. G. sleepers, or other scantlings or merchantable timber).
(*f*) The length of merchantable bole in feet.
(*g*) The volume of merchantable bole in solid cubic feet.

In addition, if desired for any definite purpose and when possible, figures will also be collected showing separately:—

(*h*) Total volume of timber (wood over 24″ in girth).
(*i*) Total volume of small wood (wood under 24″ in girth).
(*j*) Total volume of tree timber *plus* small wood.

By "*timber*" will be understood all wood over 24″ in girth: whilst "*small wood*" will include all material below this girth.

The definition of "merchantable bole," "log," and "scantling" will vary in different localities; but in each case a correct definition of each of these terms should be given in the register in which the data collected are recorded.

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* Appendix A at end.

MEASUREMENT OF TREES.

The measurements will only bear on *sound* average trees; and as a rule the collection of statistical data herein prescribed will be restricted to trees felled in the coupe of the year.

(i) *Measurement of the cubic contents of stem timber* :—The volume of the stem down to a girth of 24″ will be calculated by measuring the bole in lengths of 10 feet, the volume of each being taken as equal to—

$$\left(\frac{\text{mid-girth}}{4}\right)^2 \times \text{length},$$

Rai Kunhya Lall's tables being used for working out results.

(ii) *Measurement of the solid contents of small wood.*—All wood below 24″ in girth will be cut up into short lengths and carefully stacked; the stacked contents being converted into solid cubic feet by the use of co-efficients. Where no local co-efficients exist they should be ascertained from actual xylometer measurements and recorded for future use.

(iii) *Measurement of merchantable bole.*—The definition of "merchantable" bole will vary in different localities. It is essential that a precise definition be entered in each case in the prescribed register, Form B.*

The volume of utilizable bole measured in 10 feet lengths will be calculated from the formula—

$$\left(\frac{\text{mid-girth}}{4}\right)^2 \times \text{length},$$

Rai Kunhya Lall's tables being used to work out results.

(iv) *Outturn in scantlings.*—In localities where the timber is sawn up into sleepers or other scantlings, the exact outturn of such scantlings, in numbers and in cubic contents, should be recorded. The *exact* size and volume of the different grades of scantlings obtained should be fully recorded.

RULES FOR MEASURING TREES FOR PREPARATION OF VOLUME TABLES.

Rule 1.—Only trees of sound average growth will be selected for measurement.

Rule 2.—Trees for measurement will be selected from among those marked for fellings in the coupe of the year.

Rule 3.—The bole of the tree when felled will be divided into two portions at the point where it girths 24″ over bark. The portion above this girth being treated as "timber" and the rest as "small wood."

Rule 4.—The volume of the stem timber will be calculated by dividing the bole into 10 feet sections and calculating the volume of each section from Kunhya Lall's tables by the formula—

$$\left(\frac{\text{mid-girth}}{4}\right)^2 \times \text{length}.$$

Rule 5.—The volume of the small wood will be calculated by stacking and the "Xylometer" method, or by co-efficients if available.

Rule 6.—When the bole timber is converted into scantlings, the size and volume of scantlings should be recorded and the results entered in the prescribed register, Form B.*

SECTION 3—FORM FACTORS.

OBJECT OF EXPERIMENT.

Form factors are used to determine the actual volume of trees when girth and height are known. They may be prepared from girth measurements taken at any height from the ground; and they may relate to the whole volume of the tree (timber only or timber and small wood), or to the volume of stem timber, or to the volume of merchantable timber only.

For India, it will be advisable to prescribe the preparation of form factors based on measurements made at breast height, or 4′ 6″ from ground (that is, "*artificial*" form factors); and they should as a rule relate only to stem timber above 24″ in girth.

In addition merchantable timber form factors may also be prepared, based on the minimum size of timber, which can be disposed of in the local market.

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* Appendix B at end.

It must be remembered that form factors can only be applied in calculating the volume of a number of trees; and that they must be founded on a very large number of measurements. The form of individual trees varies so much that a satisfactory average cannot be obtained unless a very large number of trees is measured.

Calculation of Form Factors.

Only sound trees will be selected for measurement, and the experiments will usually bear only on such trees as may be felled in the coupe of the year.

The stem timber form factor will be calculated from the formula

$$\text{Stem timber form factor} = \frac{\text{Actual volume of stem timber in solid cubic feet}}{\text{* Sectional area at breast height} \times \text{total height of tree}}.$$

The actual volume of stem timber will be obtained by multiplying the $\left(\frac{\text{mid-girth}}{4}\right)^2$ of each section, by the length of each section of the stem, up to a minimum girth of 24 inches over bark.

The table of form factors to be prepared will show the form factors corresponding to given girths or heights.

Register of Form Factors.

The measurements taken will be recorded in prescribed Form C.*

Copies of all data entered in the prescribed register will be forwarded annually to the Imperial Forest Research Institute; and a table of stem form factors will then be prepared in prescribed form (Form D †) by the graphic method.

Rules for the preparation of Form Factors.

Rule 1.—Only trees of sound average growth will be selected for measurement for the purpose of preparing form factors.

Rule 2.—The selected trees will be among those marked for felling in the year's coupe.

Rule 3.—Only the portion of the bole over 24″ girth (with bark) will be taken into consideration.

Rule 4.—The volume of the stem timber will be calculated by dividing the bole into 10 feet sections and calculating the volume of each section by the formula $\left(\frac{\text{mid-girth}}{4}\right)^2 \times$ length, from Rai Kunhya Lall's tables.

Rule 5.—The volume of the tree treated as a cylinder will be calculated from the formula $\left(\frac{G}{4}\right)^2 \times H$; where G=girth at breast height and H the length of the bole in feet up to the point where girth is 24″.

Rule 6.—The results of measurements will be recorded in the prescribed register, Form C.*

CHAPTER II.—RELATING TO EXPERIMENTAL PLOTS IN HIGH FORESTS.

SECTION 1—THE COLLECTION OF DATA RELATING TO THE RATE OF GIRTH AND HEIGHT INCREMENT OF SELECTED TYPE SEEDLING TREES GROWING IN EVEN OR UNEVEN-AGED, THINNED OR UNTHINNED, SEEDLING CROPS.

Object of Experiment.

The object of such an experimental area is to determine (1) the mean annual girth increment of the trees in each girth class growing under given conditions, that is, (2) the period spent in each girth class; and hence (3) the number of years (rotation) required to produce, under those conditions, trees of given girths.

Selection of Plots and Trees.

Selection of plots and trees.—In order that these objects may be achieved two conditions are necessary:—

(i) The individuals selected for measurements should be healthy, vigorous and normally developed trees, which are likely to put on a normal

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* See Appendix C at end. † See Appendix D at end.

(or average) increment during their passage through the girth class to which they belong.

(ii) Trees representative of all the girth classes should be selected in order that the mean annual increment of each girth class may (if required) be separately determined.*

It is evident that dead and dying and wholly suppressed trees will not yield data which will assist in determining the mean annual increment of a class. For the same reason, trees situated along the edges of blanks, broad roads, fire lines or other clearings should not be selected. Again, though trees representative of all the girth classes should be selected, it is not necessary that the selection of these trees should be restricted to any given area. It is possible that the representative trees may be found all in one plot (as in the case of a selection forest); otherwise separate plots for the various girth classes may be established. The important point to be remembered is that the size of the plots will depend on the number of trees to be measured, not the reverse; and all girth classes need not necessarily be spread over an equal area.

Trees in different types of forest.—In addition it is evident that separate plots must be established for each type of forest, that is, wherever the quality of the locality varies so perceptibly as to exhibit marked differences in the development of the tree growth, *e. g.*, where the forest is situated on slopes presenting a wide range of elevation, or where the crops offer a great variety of aspects and soils.

Different species.—Each species to be brought under investigation must necessarily form the subject of a separate experiment, though no objection can exist to the trees of different species being included within the same experimental areas (*e. g.*, in a mixed forest), provided the several individuals are dealt with independently, each species being numbered and registered separately.

Preparation of Sample Plots.

The representative trees to be brought under observation having been duly selected, it will be found necessary to number them serially; to demarcate the boundaries of the sample plot; and to prepare a record fixing the position of the selected trees.

Numbering of trees.—Each species in a plot should have its own set of serial numbers: these numbers may either be painted on the bark of each tree with paint of good quality: or the numbers may be stamped on tin plates 4 inches square, which are then fixed *loosely* to the trees with wire nails, 4 inches long, driven in about $1\frac{1}{2}$ inches.

Demarcating boundaries of sample plots.—The area within which the selected type trees are situated should be carefully demarcated on the ground by a ditch, $2' \times 2'$, the salient corners being marked by good substantial posts, dressed and tarred. The form of the plots should be regular: in general the best shape is that of a long rectangle. A plan of the area on a fairly large scale (16″=1 mile) should be prepared; and a board should be set up on the edge of the plot indicating the number or name of the plot and the year in which the experiment was started.

Recording position of trees.—The position of each selected tree should if possible be recorded on a ground plan on a fairly large scale, the co-ordinates of each tree being also noted in the prescribed plot register (*vide* prescribed Form E†). These co-ordinates will be two in number, namely, the length of the offset on the base line, and the distance of the foot of the offset from the zero of the base line. In the case of plots which are more or less square, offsets could conveniently be taken from the diagonal.

Observation of Girth Increment.

Fixing point of measurement.—It is necessary that the periodical measurements be made at the same place on the stem. In order to ensure this a white ring will be painted round each tree, at the point at which the girth measurement is to be taken, the tape being always placed on the ring with the upper edges of the two coincident. The ring must be painted at right angles to the axis of the tree, with good English paint, which is likely to remain visible for a series of

* Where (as is sometimes the case in a selection forest) the object is merely to determine the mean annual increment of the trees in the penultimate girth class, it will be sufficient to select representative trees of that girth class. Similarly, as regards seedlings of the smallest girth class, special plots would probably have to be established.

† See Appendix E at end.

years, care being taken to force the brush right into the cracks in the bark. The trees selected will if possible be marked at breast height (4′ 6″ from the ground), provided the shape of the stem at this point is round and regular. On sloping ground this would be measured from the upper side of the tree. Otherwise the stem may be marked either above or below this point. Within certain limits there is no object in marking and measuring the trees at exactly the same height from the ground. The point is to measure the stem where it is regular. In order to obviate differences due to inaccuracies in the tape used for measuring, steels tapes should alone be used for the quinquennial measurements.

Time of taking measurements.—The measurements should always be taken in one and the same month. Theoretically the best time for the annual measurements would be the season when the tree is at rest, and its diameter or girth undergoes no change. This is not always possible in India, neither is it a necessity (the important point to be attended to being that a complete period of 12 months or multiple of 12 months should intervene between each consecutive measurement).

For various reasons, annual measurements will not be found of any practical utility ; and quinquennial measurements are for all present record purposes sufficient. On the other hand in order to ensure the proper maintenance of the sample plots, the renewal of the numbers and of the measuring marks, the plots should be carefully inspected annually. It will be necessary to prescribe therefore that the first measurements be always taken by a gazetted officer; and that subsequently the measurements be taken and recorded annually by range officials and quinquennially by a gazetted officer, the latter measurements alone being made use of for collation.

Classification of trees.—However carefully the trees may have originally been selected, it follows that in the course of time some of these will become suppressed, injured, &c. A careful observation of each tree will more correctly indicate how far the rate of girth increment may thereby have been affected. But in order that an indication of this may be given in the periodical records of the sample plot, it is advisable to classify the tree at each quinquennial measurement into the following classes, *viz.* :—

1. Dominant = D.
2. Dominated = $\frac{d}{1}$, $\frac{d}{2}$, d, *viz.*—

   $\frac{d}{1}$ = overtopped by a single tree on one side only.

   $\frac{d}{2}$ = overtopped half-way round.

   d = overtopped all-round.
3. Dead.

As soon as a tree passes into the third class, further measurements will of course be discontinued.

Register of plots.—The measurements taken periodically in each sample plot must be recorded in a register to be mainained in the prescribed Form E,* separate registers being maintained in the Divisional Office and at the Imperial Forest Research Institute. As already mentioned the first measurements will be taken by a gazetted officer and thereafter measurements will be taken and recorded annually by a range officer, and again quinquennially by a gazetted officer, the last measurements alone being forwarded for record to the Imperial Forest Research Institute with such observations and remarks as the Divisional Officer responsible for the same may wish to make. Great care must be taken that the measurements are always taken in one and the same month ; and in addition each tree will be classfied as "dominant," "dominated," or "dead," in the manner prescribed in a previous section.

All measurements will be recorded in inches and decimals of an inch. The recording of feet and inches separately, and the use of the "parts" of an inch must be avoided.

One register will be maintained for each sample plot, and as a rule for each species also ; though the several species under observation, in one and the same

* See Appendix E at end.

plot, may be entered in the one register, provided they occupied different portions of the same.

It is very important that the prescribed register, Form A *, should contain full particulars relating to the *situation, aspect, elevation, soil, rainfall, past history as regards fires, fellings, insect attacks*, &c., &c., of the sample plot selected; and necessary provision for all such entries have been duly made.

Calculation of mean annual girth increment.—The data relating to each 5-year period, received at the Imperial Forest Research Institute, will be collated, the mean annual increment as calculated being entered in a register in prescribed form, Form F. † The rate of mean annual girth increment will be calculated separately for each 18″ girth class and again for all girth classes combined up to 6′ and again 7′ 6″; and the results so obtained will be published in pamphlet form for each species separately at the end of each 5-year period. It would be advisable, therefore, if this is considered feasible, if all Conservators could agree to fix on one and the same year for the 5-year periodical measurements of all sample plots, so that complete data could be published periodically.

Orservation of Height Increment.

Whenever possible the height of the selected trees in each sample plot corresponding to given girths should also be recorded, as this gives perhaps the best indication of the quality of the locality ‡

Time of taking measurements.—Height measurements will be taken by a gazetted officer at the same time as the periodical girth measurements are taken, that is, quinquennially, or, where work is heavy, decennial measurements will be sufficient. In the latter case, the work could be so arranged that half the sample plots are measured alternately at the end of each 5-year period.

Instruments to be used.—When it is possible and necessary to take the height of standing type trees, the height instruments used should be of the same pattern: the name of the instrument being recorded in the register.

Register of plots.—The measurements taken will be entered in the same register prescribed for girth measurements, *vide* Form E,† in its proper column.

Calculation of mean annual height increment.—The mean annual height increment will be calculated and recorded in the same manner as the mean annual girth increment, *vide* register, Form F.§

Thinnings.

The principles on which thinnings may be carried out for the benefit of the selected type trees of a crop will necessarily differ to a certain extent from similar operations undertaken in crowded even-aged woods, with the object of obtaining the most favourable development of the whole crop. In the latter case, the thinnings would be undertaken for the benefit of the crop as a whole, whereas, in the first case, the thinnings would be solely for the benefit of the selected type trees. The removal of all trees, generally of inferior species, overtopping the selected type trees under observation would naturally form the most important feature of any such thinnings; but in addition it may also be found necessary in certain special cases to still further increase the growing space allotted to each tree under observation. Bearing these remarks in mind, artificial thinnings undertaken for the benefit of selected type trees may be divided into three classes, to be defined as follows:—

(i) Light thinnings, which would include the removal only of any trees actually overtopping the selected type trees.

(ii) Moderate thinnings, which would further include the removal only of such trees as are actually interfering with the lateral development of the crowns of the selected type trees. As a result of a moderate thinning the crowns of the selected type trees would just touch the crowns of the adjoining trees when shaken by the wind.

(iii) Heavy thinnings would further include the removal of surrounding trees so that the crowns of the selected type trees remain detached and isolated.

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* See Appendix A at end. † See Appendix E at end.

‡ It will often be impossible to directly determine periodically the height of the selected type trees whose girth increment is under observation. In such cases the heights of felled trees of various girths grown in the same locality can be utilised as described in Chapter I, section 2.

§ See Appendix F at end.

On the other hand, in the case of the measurement of type trees growing in even-aged crops, the thinnings may be carried out in accordance with the principles enunciated in Part I, Chapter II, Section 2, page 12, a heavy, moderate or light thinning being given the interpretation therein prescribed.

In carrying out so-called thinnings in uneven-aged crops the necessity of maintaining a suitable number of representative individuals of the various girth classes may frequently help in arriving at a decision as to which of the adjoining selected type trees should be removed.

In every case, the kind of thinnings (if any) contemplated should be carefully noted.

Time of carrying out the thinnings.—The intervals of time at which the thinnings should be carried out, as well as their intensity (as above defined) must be carefully laid down. As a rule the thinnings will be carried out at the time of (and immediately before) taking the quinquennial measurements.

Register of sample plots.—In the register of sample plots (Register prescribed Form E *) the fact as to whether the growing space allotted to each selected type tree is artificially regulated or not, and whether the thinning made is a heavy, moderate, or light one should be carefully entered.

RULES RELATING TO SAMPLE PLOTS ESTABLISHED WITH THE OBJECT OF DETERMINING THE RATE OF GIRTH (OR DIAMETER) AND HEIGHT INCREMENT OF SELECTED TYPE TREES GROWING (*a*) IN UNTHINNED CROPS, EVEN OR UNEVEN-AGED, (*b*) IN ARTIFICIALLY THINNED CROPS, EVEN OR UNEVEN-AGED.

Summarising what has gone before the following set of rules are obtained:—

(i) *Selection and preparation of plots.*

Rule 1.—A plot will be chosen for each type of forest, showing distinct variations in the quality of locality.

Rule 2.—The size of a plot will depend on the number of trees to be measured; not the reverse.

Rule 3.—Only selected trees will be measured, normally vigorous and healthy ones being chosen. As a rule, the following kinds of trees will not be selected:—

(*a*) Isolated ones with large crowns.
(*b*) Short and crooked ones.
(*c*) Coppice shoots.

Rule 4.—As a rule, representatives of each of the 18″ girth classes will be selected. The representative of the various girth classes may occupy one and the same or separate sample plots; and in the latter case the various sample plots need not occupy the same area.

Rule 5.—Each species will form the subject of a separate experiment, but the trees of the different species under observation may be situated within one and the same sample plot if suitable trees of more than one species are available in one place.

Rule 6.—The area of each sample plot will be demarcated by a narrow ditch (2′×2′), the salient corners being marked by pillars or by good substantial posts, dressed and tarred. As far as possible, the shape of each plot should be rectangular.

Rule 7.—Type trees will not be chosen within a distance of half a chain from the edge of a road, fire line, or other clearing.

Rule 8.—The position of each tree will be recorded—

(*a*) On a map.
(*b*) In the prescribed register, Form E. *

Rule 9.—The type trees will be serially numbered, each species in a separate series, either with numbers painted on the trunk of the tree, or with tin labels (4″×4″) loosely fixed by 4″ wire nails driven in about 1½″, the numbers being stamped (not painted) on the tins.

* See Appendix E at end.

Rule 10.—The point of girth measurement will be denoted by a band of white paint described round the bole of the tree, the following details being carefully observed :—

(*a*) The rings will be at right angles to the axis of the trees.

(*b*) The rings will be more or less at breast height from the ground, (*i. e.*, at a height of 4 feet 6 inches), but irregularities or excrescences must be scrupulously avoided.

(*c*) A good brand of zinc oxide paint will be used to avoid frequent renewals.

Rule 11.—The rings and numbers will be renewed as often as required.

Rule 12.—The thinnings to be carried out, if any, and their intensity will be carefully laid down ; the operation being described as light, moderate, or heavy in accordance with the following definitions :—

(*a*) A light thinning.—Only trees overtopping selected type trees to be removed.

(*b*) A moderate thinning.—As for (*a*) and further trees actively interfering with the lateral development of the crowns of selected type trees.

(*c*) A heavy thinning.—As for (*a*) and (*b*) and the crowns of the selected type trees to be isolated and to remain detached.

Thinnings, if any are prescribed, will be carried out in the first year when the sample plot is laid out ; and be repeated, if necessary, every five years at the time of taking measurements.

(ii) *Measurements.*

Rule 13.—Girths and heights (if taken) will be measured in the first and every fifth year by a gazetted officer ; and the results of such measurements will be forwarded to the Imperial Forest Research Institute. In addition the sample plots will be measured and reported on annually to the Divisional Officer by a range official.

Rule 14.—Provided no change is subsequently made, the month of measurement is immaterial, but one or more complete years' growth must intervene between the successive measurements.

Rule 15.—All girth measurements will be made with the upper edge of the tape touching the upper edges of the rings of paint.

Rule 16.—Steel tapes will alone be used for the quinquennial measurements and, if possible, for all others.

Rule 17.—Measurements will be taken in *inches* and decimals of an inch. " Parts " of an inch will not be used.

Rule 18.—The trees will be classified as follows :—

(*a*) Dominant =(D in register).

(*b*) Dominated=$\left(\frac{d}{1}, \frac{d}{2}\right.$ or d in register $\left.\right)$—

$\frac{d}{1}$=overtopped by a single tree on one side only.

$\frac{d}{2}$=overtopped up to half way round.

d=overtopped over half way round.

(*c*) Dead.

(iii) *Upkeep of Registers.*

Rule. 19.—The register of sample plots will be kept up in the prescribed Form E.* One copy of the prescribed register will be maintained in the Divisional Office and one copy at the Imperial Forest Research Institute.

Rule 20.—The periodical mean annual increment for each 5-year period will be calculated at the Imperial Forest Research Institute ; the results being entered in the prescribed register, Form F,† and published from time to time.

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* See Appendix E at end. † See Appendix F at end.

SECTION 2.—THE COLLECTION OF DATA RELATING TO THE RATE OF GIRTH (OR DIAMETER), HEIGHT AND VOLUME INCREMENT OF EVEN-AGED, PURE OR MIXED, ARTIFICIALLY THINNED OR UNTHINNED, SEEDLING CROPS; AND THE NUMBER OF STEMS PER UNIT OF AREA AT DIFFERENT AGES.

Object of Experimental Plots.

The development of a whole crop will usually be studied with the ultimate purpose of collecting data which will eventually lead to the preparation of *Yield Tables*. Yield tables are required to show, per unit of area, the number of stems, the mean height and girth (or diameter), the basal area, and the volume, of normal woods of different ages according to quality classes. It will be necessary therefore to collect statistical data relating to each of these factors. In addition, the wood under observation may be subjected to thinnings: and in that case the intensity of the thinnings should be clearly defined, so that the effect of such operations on the development of the crop may be fully realised.

Under present conditions of forestry in India, it will seldom be found possible to lay out and maintain experimental plots of this nature, except perhaps in the case of certain coniferous woods in the Himalayas, naturally produced, and in the case of certain Teak, Babul, Eucalyptus and Casuarina plantations. In every case, but more especially so when the sole object of such experimental plots is to prepare yield tables expeditiously, a number of plots of different ages should, if possible, be selected, such plots varying in age by periods of 10 to 20 years.

Selection of Experimental Plots.

In the selection of experimental plots suitable for studying the development of whole even-aged crops two conditions are necessary —

Firstly.—The sample plot must be of sufficient size; and

Secondly.—The plot must be fully stocked with an even-aged crop of healthy, vigorous and normally developed individuals.

The difficulty which may be experienced in selecting even-aged woods of any appreciable extent is fully recognised; but on the other hand no sample plot of less than *half an acre* in extent should be taken under observation; and not only should the area of the sample plot itself be fully and evenly stocked, but an adjoining strip of forest of similar composition should also be available.

Experimental plots may be required for each different type of forest; and either a separate plot for each different species, or the development of a mixed crop may be studied, when the species, growing together, are both equally saleable, such as Sissoo and Mulberry, Deodar and Kail, etc., etc.

Demarcation of Experimental Plot.

The experimental plot selected will be of a regular shape, preferably in the form of a rectangle; and the boundaries of the plot will be demarcated by a ditch, 2′×2′, with pillars or good substantial posts, dressed and tarred, at the corners. A board should also be erected at the edge of the plot indicating its name or number, and the year in which the experiment was started.

The outer boundaries of the sample plot should not be situated within half a chain of a blank, road, fire line, or other clearing.

A map of the experimental area on a fairly large scale will be prepared, and the position of the sample plot will also be indicated on the available forest maps of the locality.

The exact area of the experimental plot will be carefully taken out from the plan by means of a planimeter.

The dimensions on the plan will be the actual measurements taken along the slope, the average angle of the slope of the plot, in degrees, being determined and recorded.

Determining Age of the Plot.

Except in the case of plantations, whose age is definitely known, the mean age of the crop in the sample plot will be determined by ring countings on stumps of trees felled in the adjoining area of forest, the mean thus calculated being verified by countings on stumps of trees removed from time to time in thinnings, &c., in the plot itself.

Measuring the Development of the Crop.

(i) *Girth Measurements.*

Cleanings and Thinnings.—After the area of the sample plot has been demarcated, all dead and dying trees situated within the boundaries of the experimental plot will be removed; and in addition a thinning may be carried out, if prescribed.

Again, at the time of each quinquennial measurement (to be prescribed lower down) a similar cleaning and thinning would be carried out, the volume of the material so removed being carefully measured and recorded.

Fixing point of measurement.—In order that periodical measurements of the trees, forming part of the crop to be brought under observation, be made at the same place on the stem, it is necessary to paint a ring of white paint round the stem of each tree at the point at which the measurements are to be taken. This will be done in exactly the same manner as has been indicated in the case of the girth measurement of selected type tree, *vide* page 9.

The tree should also be numbered as indicated on page 8, Rule 9.

Time of taking measurements.—The plots should be measured up regularly at the end of every 5-year period, and in the same month; but, provided no change is subsequently made, it is immaterial what month is taken for the periodical measurements, provided it falls within the working season.

Method of taking girth measurements.—After the removal of the dead trees, and the carrying out of such thinnings as may have been prescribed (*vide* page 7) at the time of the periodical quinquennial measurements, the girth of all the stems forming the crop will be carefully measured separately, the exact girth of each stem being recorded in inches and decimals of an inch, and then abstracted into 6″ girth classes; and therefrom the *mean* girth will be calculated, the latter alone being entered in the prescribed register, Form G*; the detailed measurements being maintained in the Range or Divisional Office.

All girth measurements will be taken with a steel tape; the upper edge of the tape touching the upper edges of the ring as previously laid down in the case of measurement of type-trees.

From the mean girth and from the total number of stems standing on the area, the total basal area of the stems constituting the crop will be determined from the formula—

$$\left(\frac{\text{Mean girth}}{4}\right)^2 \times \text{number of stems.}$$

(ii) *Height Measurements.*

The mean height of the trees remaining in the crop after the quinquennial cleanings and thinnings have been made will be calculated from actual measurements of trees removed in such cleanings and thinnings, suppressed trees being ignored, and also from sample trees cut in adjoining areas; the result being entered in the prescribed register, Form G.*

(iii) *Number of stems and basal area.*

The girth measurements will give the total number of stems on the plot of known area as well as the "basal area" of the crop. The number of stems so determined and the total basal area of the stems will be entered in the column reserved for the purpose in the prescribed register, Form G.*

(iv) *Volume of growing stock.*

The volume of the growing stock will be divided into two parts—

(*a*) Timber.
(*b*) Small wood.

For the purpose of these experiments, timber will be defined as all parts of the stem and branches over 24 inches in girth, everything below this girth being classed as small wood.

In order to determine the volume of the growing stock at the time of the quinquennial measurements, one or more sample trees must be selected in a strip of forest adjoining the actual experimental area set aside for this purpose, the size of the sample tree being determined by the method of the arithmetical mean sample tree.† In addition the volume of the intermediate fellings must be carefully recorded (*vide* section relating to thinnings on page 12).

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* See Appendix G at end.

† *Vide* Schlich's Manual of Forestry, Volume III, page 49.

In calculating the volume of the timber of all felled trees, the volume of each section of the tree will be calculated from the mid-girth and length by using Rai Kunhya Lall's tables.

For the small wood the timber is to be stacked and measured and the results reduced to solid cubic feet by applying suitable co-efficients, the correct co-efficient for reducing being calculated from actual xylometer measurements.

The volume of the trees removed in thinnings at the time of the quinquennial measurements, and the volume of the growing stock both "timber" and "small wood" will be entered in their appropriate columns in the prescribed register, Form G.*

(v) *Calculation of the mean annual increment.*

By dividing the total volume of the wood at any age *plus* intermediate yields (*i. e.*, thinnings) by the age of the crop, the mean annual increment is obtained. This will be calculated separately for timber only, and for timber and small wood combined.

(vi) *Form Factors.*

The form factor for timber (*i. e.*, wood over 24" in girth at the smallest end) and for timber and small wood (*i. e.*, for whole volume of wood) will be calculated from the formula—

$$\text{Form factor} = \frac{\text{Actual volume of timber or timber and small wood}}{\text{(Sectional area of all trees)} \times \text{(Mean height of wood)}}.$$

The form factors so calculated will be entered in their proper place in prescribed Form G.*

REGISTER OF PLOTS.

The measurements taken periodically in each sample plot, whether these relate to the number of stems in the plot, the mean girth or height, or the mean volume of the crop and its mean annual increment, will be entered in prescribed register, Form G.* A register in this form will be maintained both in the Divisional Office and at the Imperial Forest Research Institute, copies of the quinquennial measurements being forwarded to the latter bureau for record, together with such observations and remarks as the Divisional Officer responsible for the same may wish to make, special reference being made to the factor employed in reducing stacked cubic feet of small wood to solid cubic feet.

The measurements so received will show the development of the crop on the demarcated area of the sample plot selected, whatever this area may be. At the Imperial Research Institute the data will be made applicable to an area of one acre; and the figure so deduced will be published from time to time in pamphlet form.

THINNINGS.

Whenever the crop, within which the selected trees to be brought under observation are situated, is artificially thinned, some indication will be given regarding the principles on which these fellings are to be conducted, that is, whether a *light*, *moderate*, or *heavy* thinning is to be carried out.

The difficulties which must necessarily be experienced in attempting to give an exact definition of any one of these three classes of operations will be readily realised; so much must depend on the nature of the crop, on the factors of the locality, and on the personal element. Nevertheless it is advisable, to define the nature of the operation to be carried out as nearly as possible and for this purpose the following classification given by Mr. Fernandez on pages 472—473 of his Manual of Indian Sylviculture will be prescribed:—

The individuals composing any crop may, according to the vigour and fullness of their crowns, be grouped into the following five easily distinguishable classes:—

(i) *Overtopping trees*, possessing exceptionally well-developed crowns and standing well above all the rest.

(ii) *Dominant trees*, possessing well-developed crowns. As a rule these mainly form the leaf-canopy.

(iii) *Dominated trees, i. e.*, those about to be overtopped. These are generally trees that have recently been in Class II, but owing to weaker growth, have been left behind in the race. Their crowns will be already found to be more or less contracted and in some of them incipient decline will be noticed.

* See Appendix G at end.

(iv) *Overtopped trees.*—Crowns very appreciably contracted either on every side, or on one side only. In some species the boughs and other large branches will be found bearing an abnormal number of short twigs grouped together in thick bunches. These trees may either (*a*) have the clear sky above them, but be closely hemmed in laterally, or (*b*) have only a part of their crown free, the rest being completely overshadowed. Not unfrequently many dead branches will be noticeable.

(v) *Suppressed trees.*—Such individuals, if belonging to conspicuously shade enduring species, may still have perfectly green crowns; otherwise the crowns will be found to be quite dead or in a dying condition.

It is an essential rule in making thinnings that the soil shall not be uncovered to such an extent as to expose it to deterioration and that the individual trees shall not be isolated to such an extent as to render them liable to get bent or broken. Hence the severity of a thinning will be different according to the different prevailing conditions of growth in each case. For all practical purposes, however, it is sufficient to distinguish three degrees of severity as follows:—

(1) *Light thinning.*—In which only suppressed trees are taken out. Such thinnings hardly help nature at all, but serve mainly to utilise stems that have practically ceased to exercise any impeding action on the growth of the rest of the crop.

(2) *Moderate thinnings.*—In which, besides suppressed individuals, those of category (*iv-b*) of overtopped trees and a great many of category (*iv-a*) are also removed. This will without doubt be a class of thinnings most widely used in India.

(3) *Heavy thinnings.*—In which *all* suppressed and overtopped trees must disappear, and also perhaps a few of those that are about to be overtopped.

Volume of material removed in thinnings.—The volume of the material removed in thinnings at the end of each 5-year period should be calculated by actual measurement, the wood obtained being classified as timber and small wood. The volume of the latter, which would include all wood below 24 inches in girth, would be determined by stacking the wood and using co-efficients in order to convert the stacked volume into solid cubic feet, whereas the volume of the timber will be determined by the use of Rai Kunhya Lall's tables.

The volume of thinnings obtained for each periodical operation will be entered in its proper columns in the prescribed register, Form G*.

Rules relating to Sample Plots established with the Object of determining the Rate of Girth, Height and Volume Increment of even-aged, pure or mixed, artificially thinned or unthinned Seedling Woods, and the Number of Stems per unit of area at Different Ages.

(*i*) *Selection and Preparation of Plots.*

Rule 1.—A plot will be chosen for each type of forest, the latitude, elevation above mean sea level, aspect, slope, soil, rainfall, &c., being carefully noted.

Rule 2.—Each plot will be of a suitable size, not less than half an acre in extent.

Rule 3.—Each plot will be fully stocked with an even-aged crop of healthy normally-developed trees.

Rule 4.—Each species will form the subject of a separate experiment unless the object is to determine the development of an even-aged *mixed* crop.

Rule 5.—The area of each sample plot will be demarcated by a narrow ditch (2′ × 2′), pillars or substantial posts, dressed and tarred, being erected at the corners. The shape of each sample plot should be rectangular. A board will also be erected indicating the name or number of sample plot.

Rule 6.—Sample plots should not be selected within a distance of half a chain from the edge of a blank, road, or other clearing. A strip of wood similarly stocked and similarly treated will be left adjoining the sample plot area, in order to supply the sample trees required for the calculation of the volume of crop.

Rule 7.—A plan of the sample plot on a large scale will be prepared, and the position of the experimental area will be indicated on the ordinary forest maps.

Rule 8.—Each tree in the experimental area should have a band of white paint described round the bole at the point of girth measurement, the following details being observed:—

(*a*) The rings are to be at right angles to the axis of the tree.

(*b*) The rings are to be more or less at breast height from the ground, but irregularities and excrescences must be scrupulously avoided.

* See Appendix G at end.

(*c*) A good brand of zinc oxide paint should be used to avoid frequent renewals.

(*d*) The rings must be renewed as often as required.

Rule 9.—The artificial thinnings to be carried out (if any) and their intensity will be carefully prescribed, the operation being described as light, moderate, or heavy in accordance with the following definitions :—

(*a*) Light thinning—only dead suppressed trees will be removed.

(*b*) Moderate thinning—suppressed trees and a proportion of overtopped trees will be removed.

(*c*) Heavy thinning—all suppressed and overtopped trees will be removed ; and also perhaps a few of those that are about to be overtopped.

Rule 10.—Thinnings will be carried out in the first year and every fifth year at the time of (*e. g.*, immediately preceding) the periodical measurements. Thinnings will be carried out by a Gazetted Officer. Where no special thinnings are prescribed, a cleaning to remove dead trees will be carried out, the volume of such trees being taken into account in all but the first year's measurements.

Rule 11.—The mean age of the crop will be ascertained by ring countings on stumps of trees felled in areas adjacent to the sample plot, such determination being verified by actual ring countings on stumps of trees removed from the plot from time to time in thinnings, etc.

(ii) *Measurements.*

Rule 12.—All measurements (girths, height, volume, etc.) will be taken in the first year and every fifth year by a Gazetted Officer : and the results of such measurements will be forwarded to the Imperial Forest Research Institute.

Rule 13.—So long as no change is subsequently made, the month of measurement is immaterial, provided it falls within the working season.

Rule 14.—All girth measurements will be made with the upper edge of the tape touching the upper edges of the rings, a steel tape being used.

Rule 15.—The trees constituting the crop will be enumerated in 6-inch girth classes ; and therefrom the mean girth of the crop will be calculated.

Rule 16.—The height of each tree will be taken by actual measurements of felled trees and sample trees felled in the adjoining areas for this purpose ; and the mean height carefully calculated from such measurements.

Rule 17.—In calculating the volume of the growing stock, the mean arithmetical sample tree will be calculated, and its volume obtained by felling one or more trees in the strip of forest set aside for the purpose, immediately adjoining the actual experimental area.

Rule 18.—The volume of timber, wood above a minimum girth of 24 inches, and of the small wood, wood below that girth, will be calculated separately. In calculating the volume of each sample tree, the cubic contents of each piece of timber will be obtained from Rai Kunhya Lall's tables. The volume of firewood will be calculated in stacked cubic feet, the whole being converted into solid cubic feet by the use of co-efficients.

Rule 19.—The volume of material removed in thinnings will be calculated by actually measuring the felled material in the manner prescribed for the sample trees in the preceding rule (Rule 18).

(iii) *Recording Observations.*

Rule 20.—All measurements taken will be recorded in a prescribed register in Form G.* One copy of the prescribed register will be maintained in the Divisional Office and one copy at the Imperial Forest Research Institute, the measurements recorded being forwarded to the Research Institute at the end of each 5-year period.

Rule 21.—The data received at the Imperial Forest Research Institute will be published from time to time, after reducing all measurements to the acre.

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* See Appendix G at end.

SECTION 3—THE DETERMINATION OF THE PERCENTAGE OF STEMS IN EACH GIRTH CLASS WHICH WILL PASS INTO THE NEXT HIGHER IN AN UNEVEN-AGED (SELECTION) FOREST WITHIN THE AVERAGE PERIOD AS CALCULATED FROM RING COUNTINGS OR AS ESTIMATED.

Object of Experimental Plot.

In a selection worked forest in order that the possibility may be calculated under certain of the various prescribed methods, it is necessary to ascertain the percentage of stems that are likely to pass from one girth class to the next highest within the age periods represented by the different girth classes. With 18-inch girth classes the percentages usually adopted in India are the following :—

Girth class.	Species.		
	Teak in Burma.		
II. 4½ to 6 feet			
III. 3 to 4½ feet			
IV. 1½ to 3 feet			
V. Below 1½ feet			

But these figures are not based on actual experiments. The main object then of these experiments is to collect data which will help towards a solution of this question.

As a rule experimental plots of this nature will only be established in forests for which mean annual girth increment figures already exist, or in which experimental plots to determine the rate of girth increment have been laid down.

Selection of Experimental Plots.

The data required will be obtained by the periodical re-enumeration of selected areas. Such areas must be of sufficient size, either the whole of a compartment or a portion of a compartment, provided the areas selected contain two thousand trees as a minimum. The plots should also be fairly normally stocked: but no special care is required in their selection as in each case the whole of a compartment or coupe, or a portion of the same with natural boundaries, will be selected.

If possible one plot should be selected in each coupe, or in each alternate coupe. The larger the number of plots, the more complete will be the data collected.

Demarcation of Experimental Plot.

The sample plot should either include the whole of the area of a coupe or compartment, or a portion of the same, if possible, with natural boundaries. But where artificial boundaries are necessary, a ditch 2 feet × 2 feet will be the most effective way of demarcating off the plot. It will be sufficient as a rule to show the position and boundaries of the sample plot on the 4-inch (or larger scale) map of the forest, these limits being carefully recorded.

Measurement of the Crop.

Each sample plot will be enumerated immediately after the fellings are completed in 18-inch girth classes, namely :—

Below 18 inches in girth.

From and including 18 inches and up to but not including 24 inches.

Ditto	24	,,	ditto	36	,,
Ditto	36	,,	ditto	48	,,
Ditto	48	,,	ditto	60	,,
Ditto	60	,,	ditto	72	,,

A careful record of the number of trees in each girth class will be kept. The enumeration will be carried out with callipers, graduated to show 18-inch girth classes (*i. e.*, each graduation being made equal to 5·73 inches).

The following rules will be strictly adhered to:—

(*a*) Each tree must be measured at breast height (4 feet 6 inches from the ground), that is at the same height from the ground.

(*b*) The calliper must be placed at right angles to the axis of the tree and the rule must touch the tree.

(*c*) The reading must be taken whilst the calliper rests on the tree and not after it has been withdrawn.

(*d*) Creepers, &c., found on the trees must be removed before measurement; and in the case of an abnormal swelling or indenture, the measurement must be taken above and below it and the average taken.

(*e*) In the case of a tree which is divided into two or more limbs below the fixed height of measurement, each limb must be measured and recorded as a separate tree.

(*f*) On sloping ground the enumerator should stand on the upper side; and on flat ground the measurer will always face north.

The number of seedlings in the lowest girth class may either be counted (which is preferable), or they may be merely referred to as "numerous," "wanting," &c.

At the end of the felling cycle, or any other convenient period, the sample plots will be re-enumerated in exactly the same manner. In addition, a careful record will be kept of all trees removed and all casualties (*e. g.*, dead trees, windfalls, &c.) during the period elapsing between the successive enumeration surveys.

Sound and unsound trees.—The trees will be enumerated in two categories, *viz.*, sound and unsound. Trees of all classes must be considered unsound if they have any serious defects, such as a knotty trunk with many branches low down, cracks running up the stem, a rotten base or broken top. The supervising officer will check this classification into sound and unsound trees.

Register of Plots.

The results of the various enumerations made in each of the sample plots will be recorded in a prescribed register in Form H.*

Calculation of Growth Percentages.

Knowing the average rates of growth in the different classes, it will then be possible to work out the growth percentages as follows †:—

Number of trees passed into any class is equal to—

Number of trees passed out of the class,

plus „ „ „ in the class at 2nd survey

minus „ „ „ „ 1st „

using the following symbols:—

Class.	Enumeration.		Intervals between surveys.	Class age periods.
	1st.	2nd.	Years.	Years.
Above I	a	A	n	...
I	a_1	A_1		t_1
II	a_2	A_2		t_2
III	a_3	A_3		t_3

Number of trees passing out of Class I into Class "above I" in n years ... $= A - a$.

∴ Percentage ... t_1 years ... $= \frac{100\ t_1}{a_1\ n} \times (A - a)$

Number of trees passing from Class II to Class I in n years ... $= (A - a) + (A_1 - a_1)$.

∴ Percentage ... t_2 years ... $= \frac{100\ t_2}{a_2\ n}\ (A + A_1) - (a + a_1)$.

* See Appendix H at end.

† From Notes on the collection of data as to the growth of trees and tree crops by means of sample plots, by F. A. Leete, F. C. H., I. F. S.

Number of trees passing from Class III to Class II in n years ... $= (A-a)+(A_1-a_1)+(A_2-a_2)$.

$\therefore$ Percentage ... t_3 years ... $= \frac{100\,t_3}{a_3\,n}(A+A_1+A_2)-(a+a_1+a_2)$.

The calculations of percentages will be worked out as above and also by the graphic method at the Imperial Forest Research Institute, and published from time to time, whenever sufficient data are available.

Sample Plot Rules relating to Sample Plots established with the Object of determining Growth Percentages in Crops in Selection Forest.

Selection and Preparation of Sample Plots.

Rule 1.—The boundaries of the sample plot should coincide with the boundaries of a coupe or compartment, or with part of a coupe or compartment, if possible having natural boundaries, or be demarcated by a ditch 2′ × 2′.

Rule 2.—The sample plot should be of sufficient size to include at least 2,000 trees to be observed.

Rule 3.—The boundaries of the experimental area will be clearly shown on the existing forest maps. If any blanks occur within the area of the sample plot, their position and size will be indicated, a statement being prepared to accompany the plan of plot showing—

(*a*) Wooded area; (*b*) Blanks; (*c*) Total area (*a* + *b*).

Computed Measurements.

Rule 4.—The trees standing on the area will be enumerated in 18-inch girth classes, namely:—

Below 18 inches in girth.

From and including 18 inches in girth and up to but not including 36 inches in girth.

Ditto	36	,,	ditto	54	,,
Ditto	54	,,	ditto	72	,,
Ditto	72	,,	ditto	90	,,
Ditto	90 inches and over 90 inches in girth.				

Rule 5.—The girth measurement of trees will be taken with callipers graduated to show divisions equal to 5·73 inches (*i. e.*, 18 inches in girth).

Rule 6.—Trees of different species to be measured will be entered in separate columns.

Register of the Sample Plots.

Rule 7.—A register of the sample plot will be kept up in prescribed Form H.* One copy of the prescribed register will be maintained in the Divisional Office and one copy at the Imperial Forest Research Institute.

Rule 8.—The percentages of growth for the periods intervening between successive enumerations will be calculated at the Imperial Forest Research Institute, the results being published from time to time.

Section 4—The Collection of Data relating to the Rate of Natural Thinning and to the Effects of Artificial Thinnings on the Development of a Crop.

I.—Natural Thinning.

The rate of natural thinning in an even-aged crop will be readily deduced from the data collected in the manner explained in Part I, Chapter I, Section 2. The difference between the number of stems constituting the crop at different ages in an area not artificially thinned, that is, in a crop from which only dead stems are removed, will represent the rate of natural thinning.

The manner of ascertaining the number of stems to be found per unit of area at different ages in an unthinned crop has already been fully explained in that section of this Note.

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* See Appendix H at end.

II.—The effect of artificial thinning on the development of single trees or whole crops.

It has been seen that both in the case of the collection of data relating to the development of single stems and of whole even-aged woods, artificial thinnings may be prescribed. The effect respectively of a light, moderate, or heavy thinning on the girth, height, and volume increment of single trees or whole crops may be gauged by comparing the development of each of these factors in crops subjected to one or other of these conditions.

In order that a correct comparison may be made it will be necessary to establish adjoining areas exactly similar in composition; one to be lightly, the other moderately, and the third heavily thinned in accordance with the definitions given on page 12 of this Note.

In other respects the collection of data in each experimental plot would be carried out on exactly the same lines as those set forth in Part I, Chapter II, Sections 1 and 2, of this Note; care being taken that a sufficiently large number of stems, or area, is available in each case. No area less than half an acre in extent should be taken up for such plots.

CHAPTER III.—RELATING TO COPPICE WOODS.

SECTION 1—DETERMINATION OF THE RATE OF GIRTH (OR DIAMETER) AND HEIGHT DEVELOPMENT OF SELECTED TYPE COPPICE SHOOTS, GROWING IN ARTIFICIALLY THINNED OR UNTHINNED CLUMPS.

Object of Experiment.

The object of this experiment is to determine the development in height and girth of selected coppice shoots growing under definite conditions; and consequently the number of years required to produce shoots of given dimensions and the longevity of the stools.

Method of Procedure.

The object in view may be two-fold—

(*a*) To determine the girth and height development of each of the coppice shoots produced on a selected stool; or

(*b*) To determine the girth and height development of selected coppice shoots produced on selected stools.

As the first case will not produce any definite results owing to the difficulty of distinguishing between shoots that can be profitably measured and stunted shoots that can never develop, the second case will here be considered, and only the sufficiently well developed shoots will be brought under observation.

The collection of data relating to the development of selected coppice shoots will be carried out in exactly the same manner as in the case of selected type seedling trees—*vide* Part I, Chapter II, Section 1, of this Note.

The measurements taken, and the calculation made therefrom, will likewise be recorded in prescribed registers, Forms I* and J.†

The age and girth of the stumps, their condition, and the method of dressing adopted (cut flush with the ground, cut a few inches from the ground and trimmed conically, etc.) will be recorded.

Rules for Measurement of Type Coppice Shoots for observing Girth and Height Increment.

Rule 1.—The dominant and most vigorous coppice shoots in the area selected will be observed.

Rule 2.—Not more than two shoots on each stool will be selected for measurement and at least 100 shoots of each species in every series of 5-year age gradations will be brought under observation.

Rule 3.—Each species will form the subject of a separate experiment; but the different species may be situated in one and the same coupe or compartment.

Rule 4.—Unless the coupe or compartment does not exceed 5 acres in extent the selected shoots should be concentrated in a smaller area, such area being demarcated by a boundary ditch 2′ × 2′ and shown on the map.

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* See Appendix I at end. † See Appendix J at end.

Rule 5.—Type shoots will not be selected within a distance of half a chain of a road or ride, fire line, blank or other clearing.

Rule 6.—Type shoots will be numbered by means of tin labels bearing stamped numbers tied on loosely with wire at about 5′ from the ground. The point of girth measurement will be denoted by a band of white paint round the shoot, the following details being observed :—

(*a*) The rings will be at right angles to the axis of the shoot.

(*b*) The rings will be more or less at breast height (4′ 6″) from the ground.

(*c*) A good band of white oxide paint will be used.

Rule 7.—The rings and tin labels will be renewed as often as required.

Rule 8.—If thinnings and cleanings are carried out in the areas in which type shoots are situated, the operations as regards their nature and intensity will be carefully recorded.

Measurements.

Rule 9.—The girths and heights of the type shoots will be measured in the same month yearly by a trained Forest Officer.

Rule 10.—All girth measurements will be made with a steel tape, the upper edge of which will coincide with the upper edge of the ring of paint on the shoot. The measurements will be recorded in inches and decimals of inches.

Rule 11.—At each annual measurement individuals interfering with the development of the type shoot will be removed, so that the original conditions at time of selection may continue.

Rule 12.—Height increment of the type shoots will be measured by means of a levelling staff or a bamboo divided up into 6″ lengths, the height being recorded at the same time as the girth measurement, in feet and half feet.

Register.

Rule 13.—Records of height and girth measurements of the type shoots of the different species measured, which will be kept separate, will be kept in the prescribed register Form I,* one copy being maintained in the Divisional Forest Office, the other in the Imperial Forest Research Institute.

Rule 14.—A copy of the record of annual measurements will be sent to the Imperial Forest Research Institute and the results will be collated there and published from time to time.

Rule 15.—The periodical mean annual increments for each 5-year period will be calculated at the Imperial Forest Research Institute; the results being entered in the prescribed register Form J † and published from time to time.

SECTION 2—THE DETERMINATION OF THE RATE OF GIRTH, HEIGHT AND VOLUME INCREMENT OF PURE OR MIXED COPPICE WOODS, THE CLUMPS BEING ARTIFICIALLY THINNED OR UNTHINNED.

The object of this experiment is to collect data suitable for the preparation of yield tables showing for different qualities of locality, the mean girth and the mean height of the shoots at different ages, as well as the volume which may be expected per unit of area with different rotations.

Selection of Experimental Plots.

In a systematically worked coppice forest, whether simple or with standards, the coppice age gradations occupy separate areas. In the selection of experimental plots, two procedures may therefore be followed :—

(*a*) An experimental plot of convenient size may be laid out in certain of the age gradations: the crop on them felled, and the material measured up; or

(*b*) One or more experimental plots may be laid out in suitable portions of the crop, and the development of the crop may be studied by taking measurements periodically.

As the second method involves minute measurements of a large number of stems, whose volume cannot be accurately ascertained, the first of these two methods will alone be made use of. Areas fully stocked with normally developed shoots, proceeding from sound, healthy stools will be selected; and the manner

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* See Appendix I at end. † See Appendix J at end.

in which the coppicing has been carried out, whether flush with the ground or at a given height from the ground, will be carefully indicated.

Experimental plots may be required for each species, or the development of a mixed crop may be studied.

Demarcation of Experimental Plot.

To carry out the experiment, it will be necessary to lay out plots of suitable size not less than half an acre in extent, in as many of the different age gradations as can conveniently be dealt with. These plots only require to be temporarily demarcated, and this can be done in a variety of ways, *e. g.*, by means of flags and chains or ropes; or. by means of a temporary trench with posts at the corners.

Measurement of the Crop.

(i) *Age of Crop.*

The age of crop would be known from records. This age will be entered in the prescribed register.

(ii) *Area of Experimental Plot.*

The area of each of the experimental plots will be carefully recorded. In plots selected on sloping ground the actual sides will be measured and the angle of slope recorded.

(iii) *Number of Shoots and Girth Measurements.*

Before the crop is felled, an enumeration of the coppice shoots on the area will be carried out in 3-inch girth classes separately for each species. In this way the number of shoots on the area and the average girth of the shoots will be obtained and recorded in the prescribed register, Form K*.

(iv) *Height.*

The height of the dominant shoots in the crop will be recorded separately for each species, and the average for each species calculated.

(v) *Height and Volume.*

After the mean girth at breast height and the average height has been calculated by measuring the standing crop, the whole will be felled over and stacked in suitable grades.

The volume of the growing stock in solid cubic feet will be calculated according to the following classes, separately for each species if local conditions make this necessary :—

(*a*) Material 6 inches and over in girth.
(*b*) Fagots from 3 inches and up to but not including 6 inches in girth.
(*c*) Brushwood below 3 inches in girth.
(*d*) Total of all classes.

Stacked cubic feet will be reduced to solid cubic feet by the use of co-efficients to be determined by actual xylometer measurements; the co-efficients used will be recorded in the register.

(vi) *Calculation of mean annual increment.*

The total volume of the crop at any age divided by that age will give the mean annual increment.

Register of Plots.

All measurements taken in the sample plots of different ages to be felled over will be recorded in a register in prescribed Form K.*

A register in this form will be maintained both in the Divisional office and at the Imperial Forest Research Institute (Working-plans Branch), copies of all measurements so taken being forwarded to the Superintendent of Forest Working-plans for record and publication from time to time in pamphlet form. All

* See Appendix K at end.

measurements received at the Imperial Forest Research Institute will be reduced to the unit of area, the acre.

THINNINGS.

In certain cases the removal of a proportion of the shoots produced on each stump may be prescribed in order to encourage the development of those left. In such a case the least promising and most backward of the shoots would be removed, either in one operation once during the period of the rotation, or at given intervals of time.

If sample plots are selected from areas thus thinned over, the fact will be clearly recorded in the register.

RULES RELATING TO SAMPLE PLOTS SELECTED WITH THE OBJECT OF DETERMINING THE MEAN GIRTH, NUMBER OF SHOOTS, AVERAGE HEIGHT AND MEAN VOLUME PER CLASS OF MATERIAL AND TOTAL VOLUME PER UNIT OF AREA AT DIFFERENT AGES OF PURE OR MIXED COPPICE WOODS, THE CLUMPS BEING ARTIFICIALLY THINNED OR NOT THINNED.

(i) *Selection and Preparation of Plots.*

Rule 1.—The plot will be of a suitable size, not less than half an acre in extent.

Rule 2.—The plot will be fully stocked with an even-aged crop of normally developed shoots produced from healthy stools.

Rule 3.—Each species will form the subject of a separate experiment unless the object is to determine the development of a mixed crop.

Rule 4.—The plot will be temporarily demarcated in the manner most convenient; usually by a trench with flags or posts at the corners. The shape of each sample plot will be rectangular. A board may also be erected indicating the name and number of the sample plot.

Rule 5.—Sample plots will not be selected within a half a chain from the edge of blank, road, or other clearing.

Rule 6.—The removal of any of the superfluous coppice shoots from each stump if prescribed will be carried out and the fact recorded in the register of the sample plot concerned, and the volume of the material removed, if known, will also be entered.

(ii) *Measurements.*

Rule 7.—All measurements relating to one sample area will be taken in one and the same month; and the results of such measurements will be forwarded to the Working-plans Branch of the Imperial Forest Research Institute.

Rule 8.—All girth and height measurements will be taken before the crop is felled, the girth of each shoot being measured at breast height.

Rule 9.—The shoots will be enumerated in 3-inch girth classes, and therefrom the mean girth will be calculated.

Rule 10.—The height of the dominant shoots will be taken in feet and half feet by means of a levelling staff or bamboo and the average calculated for the plot for each species separately.

Rule 11.—The material obtained from the fellings will be measured up according to the following classes:—

(*a*) Material 6 inches and over in girth.

(*b*) Material from 3 and up to but not including 6 inches in girth.

(*c*) Material under 3 inches in girth.

Rule 12.—The volume of the larger pieces of material will be calculated from the mid-girth and length; the volume of the remainder of the produce will be obtained by stacking the same and using reducing factors to get its solid content. Reducing factors will be calculated from actual xylometer measurements.

Rule 13.—By dividing the total volume of the crop in solid cubic feet by its age, the mean annual increment will be obtained.

(iii) *Record of Observations.*

Rule 14.—All measurements taken will be recorded in prescribed register in Form K*. One copy of the prescribed register will be maintained in the Divisional office, and one copy at the Imperial Forest Research Institute: copies of all measurements entered in the Divisional register being forwarded to the Research Institute.

Rule 15.—The data received at the Imperial Forest Research Institute will be published from time to time after collating and reducing all measurements to the unit, the acre.

PART II.—THE PREPARATION OF PROGRAMMES OF RESEARCH WORK.

On the assumption that Part I indicates correctly the lines on which statistical working-plans data for the principal Indian species can be collected on a standardised basis for the whole of the Indian Forest Department, it only remains to indicate as briefly and as clearly as possible how the work is to be distributed among the various provinces and divisions. With this object in view the subjoined preliminary programme has been prepared and finds place in Chapter I, but the actual details of work that can be carried out in any one Circle must be left to Conservators to arrange for, with liberty to add to the work selected as opportunity arises. Chapter II deals briefly with plots already in existence in the Central Provinces for the purpose of gathering statistical information.

CHAPTER I.—ROUGH (PROPOSED) PROGRAMME OF RESEARCH WORK BY SPECIES FOR CENTRAL PROVINCES.

Problems to be brought under observation.	Name of Province.	Name of Circle.	Name of Forest Division.	Name of Reserve and Working Circle.	Number of Sample Plots.	Remarks.
SECTION 1.—RELATING TO SAL (*SHOREA ROBUSTA*).						
I.—The determination of the rate of girth and height increment of selected type trees growing in uneven aged crops, as prescribed in Part I, Chapter II, Section 1.	Central Provinces.	Northern Circle.	1. Mandla.	1. Banjar Valley. 2. Motinala.	...	Existing sample plots will be maintained where possible, new plots being established where necessary.
	Do.	Southern Circle.	1. Balaghat.	...	...	
			2. Bilaspur.	...	...	
			3. Raipur.	...	...	
II.—The determination of the percentages of stems in each girth class which will pass into the next higher in a Selection Forest within the prescribed period, see Part I, Chapter II, Section 3. *	Central Provinces.	Northern Circle.	1. Mandla.	...	...	
	Do.	Southern Circle.	1. Balaghat.	...	...	
			2. Bilaspur.	...	...	
			3. Raipur.	...	...	
III.—The preparation of volume tables, showing for given girths, corresponding height, volume of stem timber and volume of scantlings, *vide* Part I, Chapter I, Section 2.	Central Provinces.	Northern Circle.	1. Mandla.	...	...	
	Do.	Southern Circle.	1. Balaghat.	...	...	
			2. Bilaspur.	...	...	
			3. Raipur.	...	...	

* See Appendix K at end.

Problems to be brought under investigation.	Name of Province.	Name of Circle.	Name of Forest Division.	Name of Forest Reserve or Working Circle.	Number of Sample Plots.	Remarks.
SECTION 2—RELATING TO TEAK.						
I.—Ring countings to determine the rate of girth increment, *vide* Part I, Chapter I, Section 1.	Central Provinces.	Northern Circle.	1. Saugor.			
			2. Hoshangabad.			
	Do.	Berar.	1. Melghat.			
	Do.	Southern Circle.	1. Chanda.			
			2. Bhandara			
II.—Volume Tables recording the girth, total height, age, volume of stem timber and outturn of graded timber of a selected number of sound felled trees annually, *vide* Part I, Chapter I, Section 2.	Central Provinces.	Northern Circle.	1. Saugor.			
			2 Hoshangabad.			
	Do.	Berar.	1. Melghat.			
	Do.	Southern Circle.	1. Chanda.			
			2. Bhandara			
III.—The complete enumeration periodically of the growing stock on a whole compartment, or portion of a compartment in order to determine the percentage of stems passing from one class to the next higher in the prescribed period of time, *vide* Part I, Chapter II, Section 3.	Central Provinces.	Southern Circle.	Chanda.			
SECTION 3—RELATING TO BABUL (*ACACIA ARABICA*).						
I.—The determination of the rate of girth, height, and volume increment of even-aged, pure, seedling crops, *vide* Part I, Chapter II, Section 2.	Central Provinces.	Berar ..	Akola ..	Loni ...	3	Of the 3 Sample Plots one has not been thinned, one has been thinned lightly, the other heavily.

CHAPTER II.—PROBLEMS RELATING TO THE COLLECTION OF STATISTICAL DATA BY SPECIES AT PRESENT UNDER INVESTIGATION IN THE CENTRAL PROVINCES.

Problems under investigation.	Name of Province.	Name of Circle.	Name of Forest Division.	Name of Reserve or Working Circle.	Number of Sample Plots.	Remarks.
SECTION 1—RELATING TO SAL (*SHOREA ROBUSTA*).						
I.—The determination of the rate of girth increment by experimental plots.	Central Provinces.	Southern Circle.	1. Balaghat.	Raigarh Range.	6	
	Do.	Northern Circle.	1. Mandla.	...	...	Sample Plots have been provided for in Working-plan.

Problems under investigation.	Name of Province.	Name of Circle.	Name of Forest Division.	Name of Forest Reserve or Working Circle.	Number of Sample Plots.	Remarks.
SECTION 2—RELATING TO TEAK.						
I.—The determination of the rate of girth increment.	Central Provinces.	Southern Circle.	Bhandara.	Gaikhuri range.	1	
	Do.	Berar ...	Melghat ...	Sembadoh ...	12	In a plantation.
II.—The determination of the rate of height growth of teak Coppice shoots.	Do.	Do.	Yeotmal ...	1. Yeotmal.	2	
				2. Darhwa...	2	
SECTION 3—RELATING TO BABUL (*ACACIA ARABICA*).						
I.—The determination of the rate of girth and height increment.	Central Provinces.	Berar ...	Amraoti ...	Babul Working Circle.	1	

Appendix A.

PRESCRIBED FORM A.

Register of ring countings and measurement of sapwood and bark along mean radius.

Working Circle and Felling Series.	No. of compartment.	Name of forest.	Serial No.	Average number of rings counted from centre to circumference of mean radius of 1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″	19″	20″	21″	22″	23″	24″	25″	26″	27″	28″	29″	30″	Mean thickness in inches of Sapwood.	Bark.	Calculated age of trees girth without bark. 3′	4′ 6″	6′	7′ 6″	Difference in age between trees of 4′ 6″ and 6′ in girth.	Difference in age between trees of 6′ and 7′ 6″ in girth.	Remarks.
				Corresponding to true circles with circumference of 0′ 6″	1′ 1″	1′ 7″	2′ 1″	2′ 7″	3′ 2″	3′ 8″	4′ 2″	4′ 9″	5′ 3″	5′ 9″	6′ 3″	6′ 10″	7′ 4″	7′ 10″	8′ 5″	8′ 11″	9′ 5″	9′ 11″	10′ 6″	11′ 0″	11′ 6″	12′ 1″	12′ 7″	13′ 1″	13′ 7″	14′ 2″	14′ 8″	15′ 2″	15′ 8″									
Sutlej Working Circle Chini Felling Series.	80	Boklie ...	1	11	20	30	43	52	67	82	99	118	138	159	175	189	214	257	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2·0	1·2	61	109	167	...	58	...	The last 6 columns will be filled in after calculation in the office of the Imperial Forest Research Institute.

Appendix B.

PRESCRIBED FORM B.

Name of Range———————

Measurement of Type Trees.

Name of Working Circle ———————

Species—DEODAR.

Serial No.	No. of compartment.	Girth at breast height 4′ 6″ in inches.	Total height of tree in feet.	Number of rings counted on mean radius.	Cubic contents of stem timber over 24″ girth.	Cubic contents of stem of tree.			Marketable bole.			Outturn in logs.		If sawn up, outturn in scantlings.								Remarks.
						Timber over 24″ girth.	Small underwood 24″ girth.	Total contents.	Length of marketable bole.	Mid-girth of marketable girth.	Cubic contents of marketable bole.	No.	Cubic feet.	Broad gauge sleepers.		Metre gauge sleepers.		Other scantlings.		Total.		Definition of marketable bole.
														No.	Cubic feet.	No.	Cubic feet.	No.	Cubic feet.	No.	Cubic feet.	
					Cubic Feet.				Feet.	Inches.	Cubic feet.											
1	80	90	77	157	148	...	...	...	70	72	157	...	...	18	63	...	...	4	8	22	71	

Appendix C.

PRESCRIBED FORM C.

Measurement of Type Trees.

Name of Range_____

Name of Working Circle_____

Serial No. of tree.	No. of compartment.	Total height (H) of tree in feet.	Girth (G) at breast height in inches.	Sectional area at breast height at $4\frac{1}{2}$ feet. $\left(\frac{G}{2}\right)$	Volume of clylinder in cubic feet. $\left(\frac{G}{4}\right)^2 \times H$	Actual measured volume of stem timber above 24″ girth in cubic feet.	Stem timber form factor.	Remarks.

Appendix D.

PRESCRIBED FORM D.

Table of Stem Form Factors.

Girth breast height in inches.	Height in feet.								
	40	50	60	70	80	90	100	110	120
	Average Stem Timber Form Factors.								
24 ...									
30 ...									
36 ...									
42 ...									
48 ...									
54 ...									
60 ...									
66 ...									
72 ...									
78 ...									
84 ...									
90 ...									

Appendix E.

PRESCRIBED FORM E.

Register of Sample Plots to determine the girth and height development of single trees.

Name of Reserve, Range or Working Circle_____
Civil District, Forest Circle and Province_____
Name of Sample Plot_____

Species.	Area or number of trees.	Facts to be ascertained.	Date of first measurements.	Intervals at which measurements taken.	Remarks.

DESCRIPTIVE DETAILS :—(Latitude, longitude, rainfall, elevation above mean sea level, soil, &c.)

PRESCRIBED FORM E.—(*Concld.*)

Girth class.	Tree number.	Position.		On th of 19 .				On th of 19 .				On th of 19 .			
		Base.	Offset.	Classification.	Girth in inches.	Height. Ft. In.	Remarks.	Classification.	Girth in inches.	Height. Ft. In.	Remarks.	Classification.	Girth in inches.	Height. Ft. In.	Remarks.

Appendix F.

SAMPLE FORM F.

Calculation of mean annual girth increment and mean height of single trees.

INDEX.

Province.	Forest Division.	Name of sample plot.	Species.	Page.

SAMPLE FORM F.—(*Concld.*)

Name of Sample Plot _____

Name of Forest Division _____

Name of Province _____

Girth class.	Species.	Period. 19 to 19 .			Period. 19 to 19 .			Period. 19 to 19 .			Period. 19 to 19 .		
		Number of trees.	Mean annual girth increment.	Mean height.	Number of trees.	Mean annual girth increment.	Mean height.	Number of trees.	Mean annual girth increment.	Mean height.	Number of trees.	Mean annual girth increment.	Mean height.

Appendix G.

PRESCRIBED FORM G.

Register of Sample Plots to determine the development of a whole even-aged crop.

Name of Reserve, Range or Working Circle———————————

Civil District, Forest Circle and Province———————————

Name of Sample Plot ———————————

Species.	Area of plot.	Facts to be ascertained.	Date of first measurements.	Intervals at which measurements taken.	Remarks.

DESCRIPTIVE DETAILS AND JOURNAL:—

PRESCRIBED FORM G.—(*Concld.*)

RECORD OF MEASUREMENTS.

Year of measurement.	Age of crop.	Area.	Number of stems.	Girth of mean tree at 4½′ from ground in inches.	Sectional area of all trees at breast height in square feet $\left(\frac{\text{Mean girth}}{4}\right)^2 \times$ Number of trees.	Mean height of crop in feet.	Volume of wood in cubic solid feet.			Form factor = $\frac{\text{Volume of wood}}{\text{Sectional area} \times \text{mean height.}}$		Mean annual increment = $\frac{\text{Volume}}{\text{Age in years.}}$		Intermediate Returns (thinnings) in solid cubic feet.			
														Periodic yields.		Summary of yields.	
							Timber over 24″ girth.	Small wood 24″ girth.	Total timber and small wood.	Timber over 24″ girth.	Timber and small wood.	Timber over 24″.	Timber and small wood.	Timber over 24″ girth.	Timber and small wood.	Timber over 24″ girth.	Timber and small wood.

Appendix H.

PRESCRIBED FORM H.

Register of Sample Plots to determine the rate of passing over from one girth class to the next higher within the average period as calculated from ring countings, etc., or estimated.

Name of Working Circle_____

Name of Felling Series_____

Civil District, Forest Circle and Province_____

Species_____

Name or No. of sample plot.	No. of compartment in which situated.	Area of sample plot.	Facts to be ascertained.	Date of first measurement.	Intervals at which measurements taken.

DESCRIPTIVE DETAILS AND JOURNAL:—

PRESCRIBED FORM H.—(*Concld.*)

Name or No. of Sample Plot _____ No. of Compartment in which situated _____

Area of Compartment _____ Area of Sample Plot enumerated _____

Species under observation _____

Area of sample plot.			Species and nature of operations.	Year of enumeration or recording of fellings, &c.		Result of enumerations.											Remarks.
						Sound						Unsound.					
						Girth classes						Girth classes.					
Wooded area.	Blanks.	Total.		Month.	Year.	Below 18″ and seedlings.	18″—36″.	36″—54″.	54″—72″.	72″—90″.	90″ and over.	Below 18″ and seedlings.	18″—36″	36″—54″.	54″—72 .	Over 72″.	
49	4	53	Deodar (enumerated).	July ...	1904.	Many ...	1,000	680	449	...	...	...	...	...	24	23	Enumeration results will be entered in black ink and records of fellings, casualties, &c., in red ink.
...	...	...	Blue pine (enumerated).	...	...	Many ...	...	170	96	...	...	...	...	...	5	4	

Appendix I.

PRESCRIBED FORM I.

Register of Sample Plot.

Name of Reserve, Range or Working Circle———————————

Civil District, Forest Circle and Province———————————

Name of Sample Plot———————————

Species.	Area, or number of shoots.	Facts to be ascertained.	Date of first measurement.	Intervals at which measurements taken.	Remarks.

DESCRIPTIVE DETAILS:—Latitude, longitude, rainfall, elevation, soil, &c.

PRESCRIBED FORM I.—(*Concld.*)

Age.	Serial number of stool.	Shoot No.	No. of coupe and compartment.	Species.	Measurement on 19 .			Measurement on 19 .			Measurement on 19 .			Measurement on 19 .			Measurement on 19 .		
					Girth.	Height.	Remarks.	Girth.	Height.	Remarks.	Girth.	Height.	Remarks.	Girth.	Height.	Remarks	Girth.	Height.	Remarks.

Appendix J.

PRESCRIBED FORM J.

Calculation of mean annual girth increment and mean height of selected Coppice Stools.

INDEX.

Province.	Forest Division.	Name of sample plot.	Species.	Page.

PRESCRIBED FORM J.—(*Concld.*)

Name of Sample Plot _____

Name of Forest Division _____

Name of Province _____

Age class.	Species.	Period 19 to 19 .				Period 19 to 19 .				Period 19 to 19 .				Period 19 to 19 .			
		Number of stools.	Number of shoots.	Mean annual girth increment.	Mean height.	Number of stools.	Number of shoots.	Mean annual girth increment.	Mean height.	Number of stools.	Number of shoots.	Mean annual girth increment.	Mean height.	Number of stools.	Number of shoots.	Mean annual girth increment.	Mean height.

Appendix K.

PRESCRIBED FORM K.

Register of Sample Plots to determine the Volume of Coppice Crops of different ages.

Name of Reserve, Range or Working Circle _____

Civil District, Forest Circle and Province _____

Serial No.	Species.	No. of		Area of Plot.	Facts to be ascertained.	Date of making measurements.	Remarks.
		Compartment.	Coupe.				

DESCRIPTIVE DETAILS AND JOURNAL :—

PRESCRIBED FORM K.—(*Concld.*)

RECORD OF MEASUREMENTS.

Year of measurement.	No. of		Age of crop.	Area.	Species.	Number of stools.	Average number of shoots per stool.	Girth of mean shoot at 4½′ from ground in inches.	Mean height of crop in feet.	Volume of growing stock in cubic feet solid.					Remarks.
	Compartment.	Coupe.								Material over 6 inches girth, cubic feet solid.	Material 3 to 6 inches girth, cubic feet solid.	Material under 3 inches girth, cubic feet solid.	Total of all classes, cubic feet solid.	M. A. I. in cubic feet solid.	

DISCUSSION ON MR. CACCIA'S PAPER.

Mr. Caccia in opening the discussion on his paper, said that his object in writing it was to indicate the general lines, on which investigations in connection with the collection of statistical data for the more important timber trees and principal types of forest, should be carried out, and how the information should be recorded through the whole of India, in order to allow of the data from different localities being systematically collated and compared. He urged the great importance of the experiments instituted being carried out on *identical lines* and pointed out, that up to the present date, no comparable record of measurements had been kept, and that in consequence such information as had been recorded was of very little, if any, value for statistical purposes. Owing to constant transfer of Divisional Forest Officers investigations commenced by one officer were not continued by his successor, with the unavoidable result that the majority of the observations hitherto made are rarely more than of local value and that our knowledge of the rate of growth, &c., of the more important forest trees in India was still very small. One object of the Imperial Forest Research Institute was to remedy this admitted defect by indicating the general lines upon which investigation should be made in the future, controlling them, and keeping up a record of all measurements recorded and working up, collating and publishing from time to time the information collected in different parts of India.

The lines upon which investigations should be carried out in the future were given at length in the paper presented for discussion; rules had been drawn up for the conduct of the experiments recommended, and forms suggested for the record of the measurements, &c., made, which, if adopted, would allow of the information recorded being worked up by the officers of the Imperial Research Institute and made available for use of Forest Officers in India.

The proposals set forth in the paper Mr. Caccia explained were necessarily based on general principles, as they were drawn up for the whole of India, and indicated the amount of information at present required by the Imperial Superintendent of Working Plans, and he again laid stress upon the necessity of conducting investigations on the same lines, and of their control by the Research Institute, when the general lines on which the investigations were to be made had been settled by Conservators and the Principal of the Research Institute in consultation. These principles were unanimously agreed to and embodied in *Resolutions Nos.* 1 *to* 4. Considerable apprehension was expressed as to the measure of control which would be exercised by the Imperial Research Institute over the investigations which would necessarily be carried out by local Forest Officers, who were naturally in the best position to know what information was wanted locally and what amount of detail it was practicable to obtain, and a fear was expressed that the results of the investigations, though of great value to the Research Institute, might be of very little or no practical value to the local Forest Officers. It was, however, pointed out that as Conservators would decide, in consultation with the Principal of the Research Institute, the exact nature of the investigations to be undertaken and would directly control these, the interests of the local Forest Officers should be carefully looked after.

The Conference was unanimously of opinion that the introduction of a uniform method of procedure for the whole of India, with regard to the collection and record of information, on the lines suggested by Mr. Caccia, regarding the principal Indian species, was absolutely necessary, that until this was done very little real progress could be made as regards the collection of statistics relating to the principal Indian species and recommended (*Resolution No.* 5) that, with a view to attaining this end, a Conference of Conservators, and Divisional Forest Officers with local experience, should be convened at the earliest possible date to draw up rules for the conduct of the necessary investigations, to allow of a commencement being made to collect statistical data on lines which will allow of its being collated and made available for Forest Officers in India.

Mr. Caccia's paper was then considered in detail, more especially Chapters I and III, as the greater portion of the Forests in the Central Provinces will, for some time to come, be worked as coppice woods. The rules and procedure in these chapters and generally those contained in Chapter II were approved with a few slight modifications which have been entered in the paper as printed in these

proceedings. A programme of Research work (*Resolution No.* 6) was drawn up to take the place of the programme proposed in Chapter II of Mr. Caccia's paper and the problems at present under investigation. Until new rules are authoritatively issued, it was agreed that all investigations undertaken should be conducted as far as possible on the lines laid down by Mr. Caccia. It is unlikely that all the information required by Mr. Caccia can be obtained at present, but all experiments instituted will be carried out in accordance with the rules, and the measurements recorded in the forms, drawn up by him with such evident care.

The Conference then discussed the question of the value of thinning teak coppice shoots in a mixed forest worked for the production of poles and small timber under the coppice with standards system. It was generally agreed that cleanings or thinnings were necessary to obtain the largest number of marketable poles, that the subject was one of considerable importance in the Central Provinces, and that an investigation should be undertaken with a view to determining the intensity and frequency of such thinning. Mr. Rogers pointed out that cleanings and thinnings should be made in the ordinary course of events, when the state of the crop showed that they were necessary, and that the intensity of the thinning would necessarily vary with each type of forest in which the investigations were undertaken, as well with the factors of the locality and that no hard-and-fast rules could be prescribed. The Conference considered that an experiment should be made to test the value of thinning teak coppice shoots in a mixed forest worked as coppice with standards, and recommended that the following rules, which were drawn up by Mr. C. Somers-Smith,* Deputy Conservator of Forests, Seoni Division, should be adopted :—

Rules for experiments to test the value of thinning Teak Coppice Shoots in a mixed Forest worked under Coppice with Standard Sylvicultural System.

Rule 1.—Two areas of not less than one acre each shall be selected in a coppiced area not less than five years old. The areas will be similar with respect to soil, aspect, and other conditions, and shall contain a complete normally developed crop of stool shoots from healthy stools.

Rule 2.—The areas shall if possible be contiguous, but in order to ensure similarity of conditions, may, if necessary, be selected in different forests.

Rule 3.—The areas will be demarcated by trenches 2′ by 2′ with posts at all salient angles.

Rule 4.—One area will be thinned on selection, the standing crop being carefully enumerated and the nature and quantity of material removed recorded. In this operation all crooked, badly grown, suppressed stool shoots will be removed, and only straight shoots with a good prospect of future growth will be left. All stems of inferior species which threaten to interfere with the growth of the teak stool shoots will also be cut back.

Thinnings will be repeated 5, 10, 15 and 20 years after the commencement of the experiment, when all suppressed, damaged and unnecessary stems will be removed.

Rule 5.—Twenty-five stools in each area will be selected for observation. These will be numbered consecutively and entered in a register in Form I (pages 37 and 38 of Mr. Caccia's paper).

Rule 6.—The girth at breast height (*i. e.*, 4 feet 6 inches above the ground) and height of each shoot will be measured. The *mean* girth and height of the shoots being entered in the register and the volume being calculated from the latter measurements.

Rule 7.—The measurements will be made quinquenially by a trained officer. The first measurements being taken immediately *after* the first thinning has being made.

Rule 8.—A statement showing the number of shoots removed in the thinnings———and their approximate volume———will be entered in the register at the time that the thinning is made, so that the total volume of wood in the plot will be available for comparison.

* Mr. Somers-Smith died suddenly on the 18th December 1908, and 19 days after the Conference ended, deeply regretted by all his brother officers.

Rule 9.—The plots will be inspected annually by the Range Officer who will be responsible that the boundaries and marks on the stool shoots under observation are properly maintained.

Rule 10.—Type shoots will be numbered by means of tin labels bearing stamped numbers tied on loosely with wire at about 5 feet from the ground. The point of girth measurements will be denoted by a band of white paint round the shoot, the following details being observed:—

(*a*) the rings will be at right angles to the shoot,

(*b*) the rings will be more or less at breast height (4 feet 6 inches) from the ground,

(*c*) a good band of white oxide paint will be used.

Rule 11.—The rings and tin labels will be renewed as often as required.

Rule 12.—All girth measurements will be made with a steel tape, the upper edge of which will coincide with the upper edge of the ring of paint on the shoot. The measurements will be recorded in inches and decimals of an inch.

Rule 13.—Records of height and girth measurements of the type shoots will be kept in prescribed Form I (of Mr. Caccia's paper), one copy being maintained in the Divisional Forest Office and one in the Imperial Forest Research Institute.

Rule 14.—A copy of the record of annual measurements will be sent to the Imperial Research Institute, and the results will be collated there and published from time to time.

Rule 15.—The periodical mean annual increments for each 5-year period will be calculated at the Imperial Forest Research Institute, and the results being entered in the prescribed register of Mr. Caccia's paper and published from time to time.

The resolutions passed during the discussion of Mr. Caccia's paper are appended.

RESOLUTIONS PASSED ON MR. CACCIA'S PAPER.

Resolution 1.—That the inauguration of any investigation for the collection of statistical data relating to the principal Indian species may be made either by Chief Conservators and Conservators of Forests or by the President of the Imperial Forest Research Institute.

Resolution 2.—That in order to ensure continuity of action, the exact lines upon which the investigations shall be conducted, and the rules for the record of the necessary information shall be determined by the Conservators of Forests and the President of the Imperial Forest Research Institute, and when settled, can only be altered with the consent of those officers.

Resolution 3.—That the general direction of the collection of statistical data shall be vested in the Research Officers of the Working Plans branch of the Imperial Forest Research Institute and that they be empowered to ascertain by inspection or otherwise that the investigations are being conducted upon the lines that have been agreed upon.

Resolution 4.—That copies of all measurements recorded shall be sent periodically (as may be prescribed) to the Imperial Forest Research Institute for scrutiny, record and publication.

Resolution 5.—That this Conference accepts Mr. Caccia's proposals for the lines of investigation for the collection of statistical data relating to the principal Indian species detailed in Part I of his paper, but considers that the rules laid down by him for the methods of conducting investigations require further consideration, and is of opinion that this can best be done by a Conference of Conservators and such other officers as they may invite to attend to give information on any special points.

Resolution 6.—That the following programme of Research work in the Central Provinces should be taken in hand as soon as possible.

Relating to Sâl High Forests.

1. Determination of the rate of growth and height increment of selected type trees growing in uneven-aged crops :—

Northern Circle	...	Mandla Division.
Southern Circle	...	Balaghat.
		Bilaspur.
		Raipur.

2. Determination of the percentages of stems in each girth class which will pass into the next higher within a prescribed period in forests worked by the selection method or improvement fellings :—

Northern Circle	...	Mandla Division.
Southern Circle	...	Balaghat.
		Bilaspur.
		Raipur.

3. Preparation of volume tables showing for given girths the corresponding height, volume of stem timber, volume of scantlings, other merchantable timber—

Northern Circle	...	Mandla Division.
Southern Circle	...	Balaghat.
		Bilaspur.
		Raipur.

Relating to Teak High Forests.

1. Ring countings to determine the rate of girth increment—

Northern Circle	...	Hoshangabad Division.
Southern Circle	...	North Chanda ,,
		South Chanda ,,

2. Complete enumeration, periodically, of the growing stock on a portion of a compartment, in order to determine the percentage of stems passing from one class to the next higher in a prescribed period—

Southern Circle ... South Chanda Division.

Relating to Babul.

1. The determination of the rate of girth height and volume increment of even-aged pure seedling crops—

Berar Circle ... { Amraoti Division. / Akola ,, / Buldana ,,

Relating to the ordinary Central Provinces type of Teak or mixed pole forests.

1. Ring countings or sample plots to determine the rate of girth increment of teak and

(1) teak,

(2) the species found in mixed pole forests where there is very little teak, with a view to determining the length of rotation required to produce marketable material.

Northern Circle.—To be fixed by Chief Conservator and Conservators of Forests in consultation.

Southern Circle.—To be fixed by the Chief Conservator and Conservators of Forests in consultation.

Berar Circle.—To be fixed by the Chief Conservator and Conservators of Forests in consultation.

2. The determination of the time required for teak standards in each girth class to pass into the next higher class.

Northern Circle.—To be fixed by the Chief Conservator and Conservators of Forests in consultation.

Southern Circle.—To be fixed by the Chief Conservator and Conservators of Forests in consultation.

Berar Circle.—To be fixed by the Chief Conservator and Conservators of Forests in consultation.

SECTION II

(1)—PAPER ON THE PROPAGATION AND COLLECTION OF LAC.

(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTIONS ADOPTED.

PAPER

ON

THE PROPAGATION AND COLLECTION OF LAC

BY

A. E. LOWRIE, Esq.,

Deputy Conservator of Forests, Raipur Division, Central Provinces (Southern Circle).

THE PROPAGATION AND COLLECTION OF LAC.

Much has been written, both right and wrong, on this interesting subject.

Development of insects.

We all know that lac is the production of a small Hemipterous insect belonging to the family of coccidæ named (*Tacharia lacca*). The insect itself is very minute and when seen by the naked eye, scattered about on a sheet of white paper, they resemble small dots of red ink. However their movements can be distinctly seen even thus. The scene is changed on using a magnifying glass and what appeared to be a dot of ink is transformed into an insect $\frac{1}{40}$th of an inch in length, elliptic in form, with a head to which are attached two small marginal eyes and two short antennæ. The body consists of nine segments; to these are attached three pairs of short legs, and from the last segment but one, spring two long hairs. On the sides of the thorax there are two tufts of powdery hair-like filaments, a similar tuft curling on either side of the anal orifice. At this stage the distinction between the male and female insect cannot be traced. Gradually after the insects have attached themselves to the twigs a transformation takes place; the antennæ, legs and head of the female insect disappear, and what now remains is a dark red, much swollen elliptic sac, with the proboscis at the elongated end buried in the twig and the three tufts of white hair-like filaments at the rounded end of the sac. Two of these three tufts, which are situated on the thoracic end of the insect, proceed from minute apertures and are used for the purpose of breathing, the resinous incrustation as it forms leaving the filaments free. The third bundle of hair-like filaments proceeds from the anal aperture; so much for the formation of the female insect. We will now see what has happened to the male insect who had also attached himself to the twig on swarming. Here he forms an incrustation for himself smaller than that of the female from which no white hairs protrude; in this he undergoes a change, increasing in size, farther developing the antennæ, forming an advanced type of head and lastly adding a new pair of eyes. These eyes are situated underneath. After a month and a half to two and a half months, according to climatic conditions, when his development is completed, he emerges backward from his cell through the only opening in it. On emerging he crawls along the incrusted twig and by the aid of his two eyes underneath is able to see the openings in the incrustations of lac, under which the females are fixed and which is connected with their generative organs. After impregnating the females he dies.

2. We will now take a glance at the life-history of this little insect which

Life-history.

is still imperfectly known. Many writers give more than two crops during the year, and state that there is reason to believe that there is more than one species of the insect. Now when we consider how widely distributed the lac insect is in India, and Burma, and then the great variations of climate, it is not to be wondered at that the time of swarming of the insects is not the same everywhere. In fact the swarming may vary in the same district from year to year. Again, the tree on which the swarming takes place causes a variation in the time. This is well illustrated in the swarming on "Palas" (*Butea frondosa*) and "Kusam" (*Schlichera trijuga*), the swarming on "Kusam" being a month (indeed I have known it at times to be two months) later than that on "Palas." It is just possible that this has led to the supposition that more than one species of lac insect exists. I do not think this is the case and there is nothing to show us that this is so. It is interesting to note here that the ordinary lac cultivator also tends to this belief, but then he says that from the same incrustations issue two different species called by him "Posai" and "Magai," the former being collected from a fortnight to a month earlier than the latter, but as we know that swarming extends over a month we can account for his belief.

3. During the year there are two broods which swarm from each species

Periods of swarming.

of tree infected, be it "Palas," "Kusam" or any other. The first swarming takes place in a favourable year, about the first week of August, and this provides the lac collected in the "Katki"

or cold weather crop. The next swarming takes place about the end of January and from this is gathered the "Batri" or summer crop of lac. The swarming of the insects extends to about a fortnight in the same locality.

Infection.

4. We will now follow the larvæ on their emerging from the cell. They begin by setting out in search of food attachment. As soon as this is found on a suitable twig, the insect, if a female, is permanently fixed. Cell after cell sends forth its swarms of minute insects on this search, and it is not difficult to understand that millions perish in their endeavours to reach the required twig, some are blown away by the wind and others perish through exhaustion and starvation. This swarming generally takes place very early in the morning especially on a bright sunny day. By night most of the insects have moved off in search of food while those left on the incrustations lie quiescent at night and move off in the morning, the next day and for many days the swarming is repeated. This daily swarming accounts for the aboriginal cultivator's belief that the new brood returns to the cells seven times before they finally move off.

Incrustations not an excretion but a secretion.

5. I will now take up, from observations made by me, the formation of the lac incrustation. The lac exudation begins directly after the attachment of the insects, though the larvæ are not completely covered over; this is probably done to protect them against the weather. This first incrustation is so very fine that it is not noticeable with the naked eye. It goes on increasing very slowly, and from what I have seen, is not an anal excretion, but a secretion exuding from very fine lateral pores in the body. If carefully looked at from time to time, under a magnifier, bundles of resinous secretions are dotted about along the edges of the body, and these as they go on increasing, coalesce into a cellular mass in which the female and male insects are imbedded, leaving the anal and breathing holes open. Owing to the insects attaching themselves so close together the cellular masses again coalesce and form the thick incrustations on the twigs. Hitherto all writers have described the lac incrustation as an anal excretion, but my observations have shown it to be incrustation of the nature of a sweat secretion. I am also of opinion that if this were an anal excretion, the very fine white hairy filament, on which the life of insect depends, would be very much damaged if the incrustation came from one direction instead of spreading from several points and gently coalescing. True the ventral orifice is there, not for nothing, as one soon finds out when standing under a tree on a bright sunny morning three weeks or more after the swarming has taken place. The dripping is quite as bad as if the trees were swarming with cicadas, with which we are all familiar. The drip from the lac insects is thicker and sweeter than that of the cicadas. It keeps on falling day after day on the leaves and gives at first quite a shiny appearance to the tree. But after it has accumulated for a time fungus begins to form giving the whole tree the appearance of being covered over with soot. This takes place when the crop is very nearly ready for picking. There is no mistaking a tree infected with lac from the very dark green appearance it assumes at this time. This remarkable fact in the life-history of this insect I do not find mentioned by any of those who have written about it before.

Freeing of male insect and impregnation of females.

6. Coming back to the formation of the incrustation I find that after a period of about three months the insect is completely covered over with the incrustation. Some time before this happens the male insect, now matured, issues from his cell and impregnates the females; this takes place from two to two and half months after infection, the time being dependent on climatic conditions. This is a most important time in the life-history of the insect and still more so for the lac crop itself. Should the weather be unseasonable when the male emerges from his cell, he is killed; if the heat is abnormal and the atmosphere too dry; while if it is too wet and rainy, he is washed off before impregnation takes place and thus dies. If this happens and the female has not been impregnated she also dies, the white hair-like filaments fall and the thin incrustation crumbles into a rust-like powder and is blown off the twigs. The cultivators as soon as they see the filaments falling, anticipate a bad crop. Should, however, the season be favourable and impregnation successful, the female goes on increasing for about another two and a half months; she has then reached maturity. Her sack is filled with a red

colouring matter in which float the ovaries and the incrustations are fully formed and ready for picking. We now come to the last period of her existence which extends for about a month. This is a period of rest for her, and from all appearances she is dormant and abstains from food. About this time the ovaries are being ripened and the red fluid in the sac begins to thicken. This goes on until the ovaries are quite ripe and the larvæ swarm out of them. The sac now consists of a loose outer covering with a few grains of red powder within it. Finally the female having performed her functions dies as soon as the larvæ begin to swarm.

Trees suitable for infection.

7. I now come to the second part of this paper and that is the tree suitable for infection with the lac insect. The insect feeds on the juices of many trees, but as both Mr. Stebbing in his Monograph on the Lac Insect and Sir George Watt in his Agricultural Ledger on Tacharia Lacca have given a full table of the trees on which lac is infected throughout India, I will only treat of the trees on which lac is cultivated in the Central Provinces. Foremost of these is the "Kusam" (*Schlichera trijuga*), next come the "Palas" (*Butea frondosa*), "Khair" (*Accacia catechu*), "Dhobeyne" (*Dalbergia paniculata*), "Pakar" (*Ficus infectoria*) and "Ber" (*Zizyphus jujuba*). I have also seen most excellent lac taken from (*Pitheçolobium saman*) which was growing in the camping ground at Alapilli in the Chanda District. Of the above trees I would especially recommend the infection of lac on "Kusam," a tree found in most Provinces where lac can be cultivated. The lac incrustations are of a fine golden colour and command the highest price. Next in order I would take up the cultivation of lac on "Palas", not because it comes next in quality, for the lac taken from both "Khair" and "Dhobeyne" is much finer and of more value, but because the distribution of this tree over India is so general. The lac obtained from "Palas" is of a dark colour due no doubt to the sap of the tree being so very red, it is also thin. The lac produced on "Pakar" is quite good and I have seen it of a thickness nearly equal to that of "Kusam." The cultivation of lac on a field crop "Tur" known in other parts of India as "Arhar" (*Cajanus indicus*) has been tried for the first time in the Raipur District in the swarming of the "Katki" brood. Unfortunately the hot season was quite an abnormal one, so that the experiment as far as the forming of the incrustation was concerned was a failure. The swarming of the insects on to the "Tur" in November from seed taken from the "Palas" was everything that could be desired, and with a normal year there was every reason to believe it would have been quite a success. It is quite worth while trying this experiment of infecting on "Tur", it will have many advantages over the infection on tree growth. Should it succeed, the financial results will hold their own with those obtained from cotton in the Province.

Cultivation of lac on field crops.

Enemies of lac.

8. The next point I come to is the injury done to the lac insect and the lac incrustation by its numerous enemies, some of whom have unjustly had a bad reputation given them, while others in fact do a lot of damage. I see it stated, in more than one paper, that birds and monkeys prey upon the lac insect, but my observations do not confirm this and from what one gathers from the cultivator, they agree with me, however, it may be different in other Provinces. What I have found is that birds have come to know that the lac incrustations contain grubs and for these they burrow along the incrusted twig thereby causing a certain amount of lac to be wasted. The monkey, owing to his mischievous habits, when he gets on to a lac infected tree, breaks the lac twigs and causes a certain amount of waste. In fact I have heard it stated by certain of the cultivators, who have gone one better than those who have written about the injury done by him, that the monkeys, vain creatures that they are, break up the incrustations to get the dye in order that this may colour their teeth. This may be the fashion, but unfortunately I have not seen it done.

Insect pests.

9. Of insect pests, ants are accountable for a certain amount of damage, but not much. I was told of a case in the adjoining forests of Sonekhan in the Bilaspur Division where a lot of damage had been done to the lac crop by ants. Unfortunately I could not get there to see this. A good preventative for ants is a solution made from ground yellow arsenic known as "Hartal" in the bazars, coarse sugar or molasses and

water; this should be made fairly thick and put round the trees. The greatest damage done to lac, other than from natural causes, is from the caterpillar of a moth fully dealt with in Mr. Stebbing's Monograph. I have found this moth (*Enblemma amabalis*) attacking both crops of lac on "Kusam." Another insect, a large bug, specimens of which are on the table, has done a fair amount of damage to the lac now on the trees. The insect has never been reported before, specimens have been sent for identification. No doubt it existed before but not in large numbers. This year owing to its appearance in large numbers the damage done has been noted and the insect brought to notice. The damage is done by the bug settling on the incrustated branches and inserting his proboscis through the incrustation in order to get at the female lac insect now fairly well matured, he then proceeds to suck the juice out of her and so kills her.

Unseasonable weather.

The greatest enemy to lac is unseasonable weather, too hot or too damp (excessive rain) at certain seasons of its developments. This it is which injures the crop and may ruin it entirely.

Propagation of lac.

I will now take up the propagation of lac. Mr. Stebbing in his valuable Monograph and Sir George Watt in his Agricultural Ledger on Lac have quoted the opinions of various persons who have written on this subject, but knowing that in the vast limits of its cultivation the diversity of the climatic conditions are great, I refrain from criticising any of the methods adopted for its cultivation and will restrict myself to what has been done in these Provinces, taking up the subject from the time that Mr. Mckee wrote his most interesting paper in 1875. In the Government forests of these Provinces the cultivation has never gone past the experimental stage, but it is hoped, now that the matter has been taken up in earnest, it will be pushed on to a stage other than the experimental one. For a few years after Mr. Mckee wrote, the cultivation on a small scale, chiefly on "Palas," was carried on in one or two forest divisions, this gradually dropped and royalty was taken on lac removed from the forest divisions, and the less said about this royalty the better. While this was, and is, the state of the propagation in Government forest, that in Malguzari and Zamindari has been carried out in a more or less spasmodic way until within recent years. At first, owing to the paucity of middlemen purchasers, called locally in this district "Kochias," little care was taken about the cultivation and cultivators were contented with very small returns, even unto bartering a seer or two of lac for a fistful of salt, chillies or tobacco at the local bazaars in the forests. One case I will especially mention which came to my notice in the Raipur district. It will show how completely the unfortunate cultivators of lac were in the hands of the middlemen. The man, a Kamar, the best class of lac cultivators in the district, had borrowed Rs. 6 from a middlemen during the famine of 1900 on the understanding taken in an agreement that repayment was to be made in lac. When I enquired into the case in 1905 the unfortunate cultivator had already given two hundred seers of lac and even then was not set free. It is not to be wondered at that the lac industry was very handicapped and its propagation retarded. I have no doubt that if matters were inquired into similar cases would be brought to light in all districts of the Central Provinces. Happily since 1905 the industry has improved, an impetus has been given to it by the interest taken in it by the Forest Department, more middlemen have come in who purchase the lac, and lastly the cultivator has begun to realize that lac has its value and is worth a good deal more than a fistful of salt. The good prices also in 1906 worked the cultivators up.

Cost of infection.

11. Before entering on the method of propagation employed, I would like to mention that Mr. Mckee in his paper mentions of infection, etc., per 100 trees of "Palas" to be Rs. 3-5-11 while for 100 trees of "Kusam" it would be Rs. 15. He has not taken into account the largest item of expenditure, and that is supervision. Each cultivator of lac has either to watch himself, for at least a fortnight, on swarming and for two months before swarming actually takes place, to prevent theft, or to pay for its being done. Since one man can safely look after 80 or more "Palas" and about 20 "Kusam" (of course this depends on the distance of the trees from one another), it will be seen that Mr. Mckee's figures are a good deal short of the actual estimate. I have also heard it stated that the native methods of cultivation and collection are extremely careless, but this is

by no means the case and the better class of cultivators are by no means ignorant of what should be done; in fact, except as regards scientific points, we have still got to learn a lot from them.

Rounding of the crowns of the trees infected.

12. The first essential to good cultivation is to get the crown as rounded as possible. This is especially the case with "Kusam." By so doing the maximum of incrustation is obtained for the size of trees. To obtain this, if possible, a certain number of trees, say a third, should be lopped off all branches from 6 inches to 9 inches in girth according to the species and the tree shaped. But this is not always possible, especially in the case of "Kusam," as the trees are so scattered. This lopping has received a certain amount of attention in the Raipur District. Hitherto in Government forest limits the difficulty to lac cultivation has been the procuring of labour to carry on the propagation; this has now been largely overcome by the establishment of forest villages. All over the Province this question has received attention, and taking the figures from the last Forest Provincial Annual Report, numbers of forest villages have been established. These are inhabited chiefly by aboriginal jungle folk, who require most careful handling, as I have known a whole village clear out within a few hours when hard pressed by an unscrupulous subordinate. These men are our main stay in carrying out the cultivation of lac for us.

Methods of propagation and general field.

13. There are two methods for the infection of trees, one is to leave a certain number of branches with lac on them to enable the insects to swarm on to other branches not infected before; the second method is to tie bundles containing from 3 to 6 sticks of brood lac, 6 inches to 9 inches in length, locally called "Juris" on to a tree not infected before. The number of bundles tied depend on the size of the tree. A well-grown "Kusam" of 18 inches girth, on which from 4 to 8 bundles, equivalent in weight to about 2 lbs., have been tied will give an average of 32 lbs. of stick lac during a normal year. A well-grown tree of 4 to 5 feet girth is generally infected with from 8 to 12 lbs. of brood lac which produces an average of 60 lbs. of stick lac. Of course it may be necessary to tie more bundles in each case. The maximum that I have been told on more than one occasion produced from a large sized "Kusam" was one "Boja" (384 lbs.) in one crop. I have seen 192 lbs. taken from a tree during the "Katki" or cold-weather crop. This brood stick lac is allowed generally to remain on the trees selected for this purpose, to within 10 days of the insects swarming, the cultivator knowing this to a nicety. In every case the brood sticks are taken from the same species on to which it is to be tied. Experiments are, however, being made to see if "Palas" lac can be infected on "Kusam" and *vice versâ*. The brood stick lac is then cut and spread on the ground in the house of the cultivator. This is done, to allow air to get to the stick, as lac stored in a heap clogs and generates a large amount of heat which kills the brood before they have time to swarm. As soon as the cultivator sees the first sign of the insects appearing, he at once takes the sticks and ties them up in bundles ready to be placed on to the tree. Having wrapped each bundle loosely in straw he ties them on to the tree selected for infection with more straw or strips of (*Phœnix acaulis*) to branches from 12 to 15 inches in girth, so that as the insects swarm they move on to the succulent branches and attaching themselves produce lac. In connection with this swarming the cultivators have an idea that the brood put out to swarm at the end of July or early in August elect to swarm on the lower branches of the trees and do not crawl up high owing to the cold, that the brood put out in February crawls high, even if the bundles are tied low, in order to keep out of the reach of fires. There may be some truth in this saying which requires further investigation. Sufficient attention is not paid at present in tying the bundles of brood stick lac on the trees. The direction from which the wind blows is neglected. This is a very essential point in the propagation, as on it depends the infection of branches where, otherwise, the insects could not have crawled. Of course some of the branches have to be tied against the wind, but the majority of the bundles should be tied to branches on the side of the tree which first catches the wind, so that as many of the insects as possible blown away by the wind should be caught up by the leaves and branches. I have more than once seen root shoots of "Kusam" close to the ground very

thickly infected with good lac from insects blown down by the wind. The brood stick lac called locally "Lora" after infection is taken down and broken into "Dal" lac; this is what is known in the lac market as "Phunki" and locally as "Phuswa." Now considering that about 10 per cent of the crop is used in a normal year for infection, this "Phuswa" lac is valuable.

Period of watch by infection.

14. One must not consider that the cultivator's work is done once he has placed the brood stick lac on the trees. He has then, for a full fortnight, to keep ward and watch until every cell has been emptied of its swarm of insects and he can bring home the "Phuswa" lac without it being stolen. Again for two months before he collects the lac he has to watch for a similar purpose and prevent theft. Lac is valuable and a seer or two can be easily put away. Taking the cultivation on "Kusam" the cultivator has an idea that there are two varieties of this tree, one the small curly-leafed one, and the other the large-leafed. Only as a last resource will he touch the small-leafed tree for infection; his idea is that the sap is very acrid and the insects die on attachment. There is no doubt that there is something in this, for the lac produced on the curly-leafed "Kusam" is very poor. This requires investigation. I have noted on the two methods of infection, but there is no doubt that the one where the bundles of brood stick lac are tied is the one that should be generally adopted; a combination of the two is sometimes an advantage and should be and is adopted. As often as possible the "Juris" should be fastened where the branches fork to enable the insects to crawl up either branch.

Varieties of kusam.

Rotation of trees.

15. A form of rotation of trees for infection is employed to enable the lopped trees to recover a good growth. It takes three years for a lopped tree to recover a growth which will be of any use for infection.

Two crops of lac.

16. Since there are two crops of lac during the year, the "Katki" and "Batri," the infection in each case follows on the lines of that already detailed. It being recognized by all that the "Katki" or winter crop is the most valuable of the two.

Method of collection of incrustation.

17. I now come to the collection of the resinous incrustations in a normal season beginning with the picking of the "Katki" crop. The exact time of picking when the men and women start this, is largely dependent on what the state of the field crops are like. If it has been a good a season and the crops are good the picking is delayed, if not it is taken up a few days earlier, in order to get some ready cash, or for barter in grain at the local bazaars. The picking from "Palas" is done in November while from "Kusam" it is taken in December. After keeping a certain number of trees for seed for the next crop, the cultivator lops all the branches on which the incrustations are found. It may be that the whole of the branches are lopped from the tree, in which case the tree has a rest of three years until the new branches are sufficiently developed for a new infection, or it may be that half the tree or even more has no incrustations on its branches, if so these branches are infected for the next crop. After the branches with the incrustations are lopped they are allowed to fall to the ground where the household join in picking whatever lac has fallen off the twigs on to the ground and in cutting off the stick lac which is collected and taken home in bundles where it is sold to the purchasers either as stick lac, or the incrustations are picked off the sticks and sold as "Dal;" this latter commands a much higher price. The next crop is the "Batri" or summer crop collected in June off the "Palas" and from the "Kusam" in July; the same procedure is followed as in the "Katki" crop and so the cycle moves on.

Experiments in Raipur Forest Division.

18. I will now make a few remarks in connection with the experiments which were taken in hand and have now been developed over the whole of the Government forests in the Raipur Division. The experiments were first started in the Laon and Sirpur Ranges and enumerations of the number of "Kusam" fit for infection were made which resulted in 20,000 trees being found; on this an estimate of 150,000 trees for the whole Division was taken; this is below rather than over the number. By the help of forest villagers 1,076 trees were infected for the "Batri" or summer crop of 1906 on the understanding that they should

receive ¾ths of the crop while Government took ¼th; the crop was poor owing to climatic conditions. However from seed taken from this crop 1,968 trees were infected for the "Katki" or winter crop. The lease also in other ranges having expired, it was determined not to lease the crop but to work it departmentally, a nominal royalty being fixed per tree for a certain number of trees while others were allowed free for seed purposes. In these ranges 2,894 trees were infected. In all a total of 4,862 trees were infected in the Government forests. Registers were now started and each tree infected was numbered with a tin ticket, the numbers running serially so that the history of each tree could be kept for five years. Range registers were also started in a slightly different form. In case these forms may prove of use, I append a copy in a note attached to this paper. As it belongs to the crop of this season, I will here quote an extract from the Raipur Forest Divisional Report for 1906-07:—"One of the Gond Malguzars in Sihawa, of whom there are very few in the Province left, was badly in debt, to the extent of about Rs. 1,500. To save the village from falling into the hands of a Muhammadan, who had advanced the money, a local banker was induced by the Deputy Commissioner to lend the amount and to accept repayment in instalments by the sale of lac infected by the Malguzar in his malguzari area. The trees were personally inspected and 75 trees out of 300 were found to have lac. The Range Officer was told to keep an eye on these and collect the lac and sell it when picked. Twenty-five trees where kept for seed, and lac was picked off 50, which was sold and realized Rs. 500, the amount being paid towards the debt,"—not bad for one crop? 14,621 trees were infected for the cold-weather crop of 1907, but unfortunately the crop was a very poor one chiefly owing to climatic conditions and partly to the ravages of the larvæ of *Eublemma amabalish.* Lac was actually picked off 13,252 trees and this yielded in "Dal" lac 46,998 lbs., the Government share being 14,590 lbs. now that the 7th share had been introduced throughout all the ranges. This Government share on dryage yielded 11,988 lbs. of "Dal" lac which was sold for Rs. 3,742 or Rs. 9-5-9 per lac maund of 32 lbs. against an average of Rs. 25 per lac maund for the winter crop of 1906. Besides the 46,998 lbs. picked for sale nearly an equal quantity of stick lac was left for seed to infect the 17,923 trees for the summer crop of 1908. Now taking the yield at say, 140,994 lbs. for the season's crop in stick lac the average per tree infected comes to 9¾ lbs. which is a small yield as compared with what may be expected from a normal crop. The ¾ths share of lac belonging to forest villagers was sold at the then market rates, under the personal supervision of the Range Officer, and the money handed over at once. As the work has largely extended a special establishment has had to be entertained. To Mr. D. N. Avasia, Extra-Assistant Conservator of Forests, is due the credit of having carried on the experiments and worked them up in the Raipur Division, for, prior to 1906, there was no lac taken from the Government forests. Now the figures given show what has been done.

Analysis of lac incrustations.

19. It will not be out of place to here give an extract from Mr. Stebbing's interesting Monograph on the Analysis of Lac. The analyses were made by Dr. Hooper of the Indian Museum at Calcutta. His first analysis was that of the larvæ of the lac insect and is given as follows:—

(*a*)—

"Wax and fat	1·5
Soluble colouring matter	48·0
Insoluble albumen	42·0
Ash	8·5
	100·0

The insects contained therefore about half their weight of red colouring matter, or a ratio of 143 to 100 of albuminous remains."

(*b*) Again taking the analysis of lac incrustation, from which the larvæ had swarmed, sent from the Raipur District:—

"Volatile matter	2·3
Resin	90·5
Colour	1·4
Albuminous matter	5·2
Ash	·6
	100·0

This is a good lac and richer in resin than any other kind I have examined. The ratio of colour to the insoluble albuminous matter is 26·9 to 100."

The next is an analysis made by the Imperial Forest Chemist of clogged lac sent to him. This lac owing to its having been carelessly transported in a bundle, without being aired, generated heat and clogged into a solid mass of a dark red colour. It was found to be about half the weight of the ordinary incrustation and a chemical change being anticipated it was sent for analysis. This requires further investigation :—

(*c*) Clogged lac—	
Moisture	1·79
Resin	75·20
Colour	4·93
Albuminous matter	14·93
Ash	3·15
	100·0

It would be interesting to know what it is that causes the clogged lac to become so light.

Phunki lac not free from colouring matter.

20. From the above figures it will be seen that "Phunki" lac is not free from colouring matter. Now that lac dye is of no value, it was considered that Phunki lac if sold by the cultivator would give him a higher price than what he would get from lac ordinarily put on the market by him. From the cultivator's point there are many disadvantages in allowing his lac to become "Phunki". First he loses in dryage, a large item for him, since we know that lac in drying loses from about 12 to 15 per cent of its weight. The value whether the lac is "Phunki" or green lac is exactly the same in the local markets to which the cultivator brings his produce. He has also got to keep watch against theft while the green lac is turned into "Phunki," and lastly very often he cannot afford to wait for the price of the "Phunki" lac even if it may be higher as he is in want of ready cash, the prices being quite good for green lac.

The export trade of lac.

21. I will now deal with the export trade of lac. The uses of lac have been known through centuries both for its rich red colouring matter as well as for its resinous incrustation. India being the great lac producing country the export trade adds greatly to her revenue, and when we see that over three crores were realized in the exports by sea for lac during 1906-07, we wonder why more attention has not been paid to this source of minor forest produce in the past. Figures worthy of note have been before us ever since 1894-95, in which the above has gone into crores. Besides the lac exported very large quantities are used locally in the country for various industries.

22. Quoting from figures regarding lac in the Review of the Trade of India in 1907-08 by C. W. E. Cotton, I. C. S., we bring our facts up to 31st March 1908 :—

"Lac has risen continously in price in recent years, in sympathy with increased external demands, and though there is no immediate likelihood of India losing her place as the chief source of supply, the more scientific cultivation and harvesting of the crop has for some time past been engaging the attention of the Forest Department. Unfortunately much of the lac comes from forests in Native States where no urgency for conservancy and development at present exists.

"Shellac and button-lac represent the manufactured article, stick and seed-lac the raw material, but the distinction is somewhat unreal, and the trade is not so distinct as to justify separate treatment. The figures of quantities and values exported during the last three years are as under—

		Cwt.	Rs.		£.
1905-06 ...	Shellac	217,593	2,64,53,774	=	1,763,585
	Button-lac	41,851	44,41,287	=	296,086
	Total ...	259,444	3,08,95,061	=	2,059,671
	Stick and seed-lac	11,004	7,79,613	=	51,974

			Cwt.	Rs.		£.
1906-07	Shellac	... ..	205,473	2,89,75,551	=	1,931,704
	Button-lac	.. ...	37,117	44,45,914	=	296,394
		Total ...	242,590	3,34,21,465	=	2.228,098
	Stick and seed-lac	... ...	15,188	12,86,242	=	85,749
1907-08	Shellac	... ...	278,338	3,32,38,167	=	2,215,878
	Button-lac	... ...	39,512	46,80,489	=	312,032
		Total ...	317,850	3,79,18,656	=	2,527,910
	Stick and seed-lac	... ...	22,740	20,59,704	=	137,314

"It may be assumed that a given quantity of stick-lac and seed-lac yields in the factory half quantity of shell or button-lac.

"There has been a quantitative rise of 35·5 per cent in shellac, accompanied by an increase of 14·7 per cent in total value, and in button-lac of 6·4 per cent in quantity and 5·3 per cent in value. Together the two increased by 31 per cent in quantity and by 13·5 per cent in value, the difference marking a decrease in specific value by 13·4 per cent. On the other hand crude material stick-lac and seed-lac increased by 49·7 per cent in quantity and 60·1 per cent in total value, equivalent to a rise of 6·9 per cent in specific value, but conclusions deduced from declared values in the case of exports not subject to duty are notoriously unsafe.

"The highest price for shellac (T. N.) in the year under report was Rs. 156·5 (£10 8*s.* 8*d.*) per cwt. in April 1907 and the lowest Rs. 68 (£4 10*s.* 8*d.*) in November 1907. These show a much wider range of prices than the maximum and minimum in the previous year, which were Rs. 155·3 (£10 6*s.* 11*d.*) and Rs. 126·9 (£8 9*s.* 2*d.*) respectively.

"The United States continued the principal buyer of the manufactured article and took lac to the value of Rs. 134·45 lakhs (£896,000) in 1907-08 against Rs. 167·95 lakhs (£1,120,000) in 1906-07. Shipments to the United Kingdom increased from 91·47 lakhs (£610,000) to 119·02 lakhs (£793,000), while Germany took Rs. 98·58 lakhs (£657,000) in place of Rs. 58·66 lakhs (£391,000) in 1906-07."

I now append a statement, kindly made out for me by the Assistant Director of Statistics, Department of Commerce and Industry, showing the exports of lac to each country. From this it will be seen that the consumption has steadily increased:—

Lac exported by sea from British India to foreign countries during the year 1900-01 *to* 1907-08.

	1900-01.		1901-02.		1902-03.		1903-04.		1904-05.		1905-06.		1906-07.		1907-08.	
	Cwt.	Rs.	Cwt.	Rs.	Cwt.	Rs.	Cwt.	Rs.	Cwt.	Rs.	Cwt.	Rs.	Cwt.	Rs.	Cwt.	Rs.
British Empire ...	78,294	36,96,553	64,681	40,14,120	114,837	87,27,552	118,030	1,35,46,603	180,242	1,44,30,779	84,104	97,34,670	72,742	95,38,663	105,603	1,23,05,795
United States of America ...	68,913	33,16,966	64,661	39,91,795	82,021	66,85,163	76,153	90,66,859	87,179	1,08,69,549	1,28,358	1,49,52,420	130,158	1,67,627	119,822	1,34,45,544
Germany ...	44,455	20,16,246	15,093	8,25,173	28,098	19,27,743	27,357	30,08,147	26,028	31,08,778	38,659	44,02,245	46,850	58,66,565	92,678	98,58,496
Holland ...	11,813	5,38,436	3,376	1,68,995	4,121	3,55,280	3,399	3,88,420	3,656	3,57,725	6,176	7,27,356	6,293	8,37,055	12,062	14,22,285
France ...	10,396	4,82,338	5,032	3,80,894	4,994	4,05,825	6,453	7,53,026	7,540	9,31,893	10,128	11,77,888	5,403	7,30,934	16,837	18,97,603
Austria Hungary ...	8,549	3,94,916	2,907	1,56,870	2,594	2,17,410	2,332	2,47,700	3,515	4,37,735	3,988	4,57,410	5,158	6,94,967	8,758	9,63,666
Italy ...	2,006	85,656	397	16,926	1,357	1,08,520	684	81,990	1,936	2,54,161	1,451	1,76,170	2,223	3,23,600	3,792	4,64,541
Belgium ...	1,935	90,590	664	20,750	258	20,900	568	59,938	166	25,875	390	41,750	170	22,800	414	44,050
Japan ...	430	20,055	164	12,799	542	44,639	446	62,058	1,533	2,06,174	837	1,02,124	972	1,45,229	1,732	2,28,876
Spain ...	110	4,650	...	...	74	5,800	...	...	...	...	...	...	37	5,000	132	14,400
Philippines ...	66	2,810	...	...	19	1,460	1	150	22	2,960	31	4,140	27	2,902	103	14,027
China (exclusive of Hong-kong and Malta).	43	1,874	79	6,940	81	6,390	160	20,154	70	8,368	62	6,312	146	19,880	57	6,600
Turkey, Asiatic ...	26	1,088	3	150	6	400	16	2,160	28	3,423	16	1,929	39	5,737	87	8,328
Java ...	18	720	1	100	3	280	...	...	23	2,372	95	10,542	37	5,000	376	37,234
Arabia ...	9	396	8	527	5	410	5	370	10	1,219	18	1,635	11	1,049	...	...
Sweden ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	694	93,000
Egypt ...	...	...	...	...	2	100	5	320	42	5,985	25	2,650	4	714	190	24,863
Turkey, European ...	3	130	3	140	...	...	7	750	36	4,250	1	150	4	596	...	...
Siam ...	...	...	...	...	...	...	...	...	...	...	9	840	9	1,200	19	1,120
Mexico ...	...	...	...	...	...	...	...	...	100	12,500	...	...	...	...	...	...
Other foreign countries ...	3	160	2	100	1	30	4	345	5	375	7	936	3	492	1	160
Total Lac ...	227,069	1,06,53,984	157,071	96,05,279	2,39,013	1,85,07,872	235,620	2,72,38,970	240,131	3,07,64,121	274,445	3,18,01,161	269,276	3,49,97,740	3,62,748	4,08,30,591

Coming now to bazaar prices for shellac at Calcutta, I give a statement from 1903-04 to 1907-08. It will be seen that the prices fell in January 1908 lower than those given by Mr. Cotton for November 1907. The price of shellac still continues low, but there is no doubt that with a more healthy state of the market in the United States they will rise again:—

Price per bazaar maund (82,286 *lbs.*) *of shell-lac* (*T. N.*) *in the first week of April, July, October and January for the years* 1903-04 *to* 1907-08.

	1903-04.	1904-05.	1905-06.	1906-07.	1907-08.
	Rs.	Rs.	Rs.	Rs.	Rs.
April	57	122	77	93	115
July	70	106	74	110	101
October	100	81	89	111	66
January	104	75	85	107	64

Chief source of lac exported.

23. I will now give a short extract from Sir George Watt's Agricultural Ledger on lac and its industries:—

"The rail-borne returns similarly manifest the fact that the Central Provinces constitute one of the chief sources of the article exported from india *viâ* Calcutta. But Assam also sends a fairly constant supply to the Metropolis. While every Province in India possesses lac, the supplies are mostly used up locally, except in the case of the Central Provinces, Bengal, Assam and Burmah, where there are available for the foreign traffic large surplus stocks over local demand. Calcutta is the chief emporium of the trade and India might almost be spoken of as enjoying a monopoly in the world's supply."

Forms in which lac is exported.

Lac is almost solely exported in the form of shell-lac and this can only be turned out at the factories. Here also is turned out the button-lac which with the lac taken from the stick-lac and known as "Dal" is chiefly used in the country. Regarding the manufacture of shell-lac and other forms of lac at the factories I will say nothing as these have been dealt with in the Agricultural Ledger, but it is acknowledged that the methods employed are crude, more mechanical power being required. I should like, however, to make a few remarks on the above extract and the figures showing the exports from the Central Provinces. Why is it that we have to depend on foreign factories for turning our lac into shell-lac? Why have we not got our own factories for this purpose? One could understand this when places like Mirzapore were situated on the Railway while the Central Provinces was badly off for Railways. Surely this is not the case now, and shell-lac taken from our own factories straight to the big firms dealing in lac would be cheaper than "Dal" lac taken to the factories in Bengal and there converting it. Taking the figures from the rail-borne trafic of the Central Provinces for lac we have—

Year.	Quantity. Cwt.	Value. Rs.
1904-05	49,867	26,56,897
1905-06	87,682	45,82,963
1906-07	44,167	27,17,200

These figures speak for themselves and show that even though the quantities and value fluctuate from year to year they are encouraging enough to show that factories are required and that they would pay.

Export of "Dal" lac from Raipur District.

25. Now dealing with the export figure of the Raipur District with which I am best aquainted and for which I have been able to get reliable figures, I give those for the last four years showing that the exports have been on the increase. The whole of this lac was removed as "Dal":—

Year.	Quantity. Cwt.
1904	2,311
1905	13,245
1906	14,569
1907	14,737

26. The uses of lac are numerous both in India and out of it. In India it enters largely into the agricultural, artistic and domestic workings of the people. In towns and most of the large villages it is used either as a varnish or a colour medium in the production of tables, chairs, bed-posts, toys, plates, &c. Silversmiths, coppersmiths and carriage manufactures employ it in their works. In the painted pottery industries in Bengal, Lucknow, Oudh and the Punjab and by the makers of bangles throughout India it is generally used. Its use in the form of a spirit varnish is spreading in India.

In Europe and America it is largely used as a spirit varnish and a polish for furniture and metal ware, as a stiffening material for hats, as an ingredient in lithographic inks and as sealing wax. Owing to the increased demand for it as a varnish and lacquer in the manufacture of motors, cycles, bedsteads and gramophone records the supply is far short of the demand, and there is every reason to anticipate a great expansion of the Industry.

27. I will now say a few words of its uses in the Central Provinces. The principal form in which it is used is the manufacture of "Churis" or bracelets. For this, refuse lac added to earth in the proportion of 3 to 1 is used. It is boiled until thoroughly mixed and this mixture when in a plastic state is made into bracelets. These are variously coloured and varnished before being sold in the bazaars. Glass bangles within late years have cut out this industry somewhat. Next to the manufacture of bangles we have the filling in with lac of gold jewellery. Here also refuse lac is used mixed with fine sand and resin; this when melted and mixed is poured into the hollows where it hardens and prevents their being druted; it also gives the ornament an appearance of being solid. Little has been done in the manufacture of toys or turnery where coloured sticks of lac are used to give the wooden surface a coating. For fear of making this paper too bulky I would recommend, those who want more information on this subject and are interested in it, to refer to Sir George Watt's Agricultural Ledger on Lac and its industries. They will find themselves quite well repaid. In the matter of the timbers used in the lac industry I would also refer them to the same source and also to Mr. Stebbing's Monograph on Lac.

Lac dye.

28. The collection of lac dye as we know has entirely gone under, having been killed out by the cheaper aniline dyes. It is interesting to have a glance at the figures showing the decline in value of this product. In 1868-69 the exports of this product were valued at Rs. 7,96,655, in 1878-79 Rs. 1,95,285, in 1888-89 Rs. 334, and in 1898-99 Rs. 6. We may say that they dropped in value within thirty years from £80,000 to eight shillings.

Conclusion.

29. In closing the paper I trust that this important source of minor forest produce will receive more attention in the future than it has had in the past and also that factories will soon be started where the Central Provinces can convert all its lac into shell-lac without having to depend on factories outside the Provinces.

In conclusion I must apologise for the defects of this paper in not having made it as interesting as I should have liked it to have been.

FORM No. 1.

History of trees infected with lac.

Name of Range.	Name of village.	Locality.	Number of trees infected.	Species.	Girth.	Number of bundles tied and the yield obtained.																Remarks.
						1906-07.				1907-08.				1908-09.				1909-10.				1910-11.				
						Batri.		Katki.		Batri.		Katki.		Batri.		Katki.		Batri.		Katki.		Batri.		Katki.		
						Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	Bundles tied.	Outturn.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

FORM No. 2.

Abstract of yield and value.

Name of Range.	Name of the forests.	Name of cultivators.	Number of trees previously infected.		Number of trees infected during the season.		Number of old trees left out.		Total.		Estimated value at present market rates.	Total sold.	Value of Government share actually sold.	Remarks.
			Abstract.	Number.	Abstract.	Number.	Abstract.	Number.	Outturn.	Government share one quarter.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

FORM No. 3.

Range List for Katki Crop, 1906-07.

Serial No. of village.	Number of trees cultivated (lac sown in forest).	Tin ticket No. as given from Head office.	Name of villager infecting tree with lac seed.	Village.	Detail of lac given as taccavi						Situation of tree.	Girth.	Number of bundles tied.	New trees cultivated.	Old trees cultivated.	Total number of trees.	Produce from trees katki crop.	
					Last year.		Current year.		Total.								¼ share of lac to Government.	Tenant ¾ share of lac.
					Lac.	Amount	Lac.	Amount.	Lac.	Total.								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1	550	A	B	Seers.		Seers.		Seers.		On edge of Forest north of village.	4′—6″	7	1	...	3	Seers. 20	Seers. 60
2	1	551			...	...	...	...	...	...		1′—6″	4	...	1			
3	1	559										3′	6	...	1			

DISCUSSION ON MR. LOWRIE'S PAPER.

Collection of lac by lease or by departmental agency.

The advantages and disadvantages of departmental, as contrasted with "contract," collection of lac were first discussed. It was generally admitted that it was impossible to lay down any hard-and-fast rule on this subject; that under certain conditions departmental collection was advisable, while under others, the only practical procedure to follow would be to lease the right to collect lac from definite areas for a term of years. It was admitted that it is very difficult for Government to prevent theft of lac if the trees, as is generally the case with *kusam*, are scattered, in small numbers, over a large area, whereas if the lac is grown on *palas* which usually occurs in pure woods, departmental working would probably prove to be the most remunerative. If the right to collect lac was sold the lease should be for not less than 3 or more than 7 years. The lac crop being an uncertain one, it is necessary to give the contract for several years to allow of the contractor making good his losses in the bad years, and also of his getting a return from the money spent on increasing the quantity of lac in the forest by artificial means. It would also be necessary to allow a lessee to renew his lease, if he was willing to give the price offered by any other competitor, when the right to collect lac was put up to auction at the end of his lease, in order to induce him to increase the quantity of lac in the forest. Conditions should be entered in the lease which would ensure that the crop of lac in the forest if not actually increased would be maintained. *Resolution No.* 7 was then framed and passed by the conference.

Different methods of harvesting lac.

The different methods of the actual harvesting of lac were then described and discussed. The method adopted in Raipur of leaving a certain number of trees for "seed" and collecting all the incrustations on the other trees is not universally followed in the Central Provinces. In the Jubbulpure, Melghat and Betul Divisions it is usual to collect two-thirds of the lac from each tree infected and to leave the remaining third (usually on the upper branches of the tree) for seed. In the Raipur system the trees are infected artificially every year. In the other divisions it spreads naturally from the "seed" left on the trees, and trees are only artificially infected in order to increase the number of lac bearing trees in the forests.

The advantages claimed for the Raipur system is that it is much easier to prevent theft of seed lac if it is only left on a few trees; on the other hand, if some seed lac is left on each infected tree, no artificial infection is necessary as the trees become naturally infected by the young insects which come out of the incrustations left in the trees. As no experiments as to the comparative merits of the two methods of harvesting lac have been made, the Conference resolved (*Resolution No.* 8) that an enquiry should be made into the advantages and disadvantages of the two systems at present followed.

Effect of cultivation of lac on the trees infected.

The effect of the cultivation of lac on (1) the growth, (2) the quality of the wood of the tree on which it was grown was then discussed, and the question of the advisability of limiting the cultivation of lac to trees whose timber was of little value considered. Another point raised was the advisability of cultivating lac in thinly stocked areas where the maintenance of the forest itself was of great importance from a climatic point of view.

In addition to the trees mentioned by Mr. Lowrie in his paper as hosts of the lac insect it appears that in the Northern and Berar Circles lac is grown on Zizyphus xylopyra (*Ghatol*) in the Kinwat Reserve, Yeotmal District, on Ougeinia dalbergioides (*Tiwas*), while in Sind Mr. Maitland-Kirwan informed us that it was almost exclusively grown on Acacia arabica (*Babul*) and Prosopis spicigera (*Jhand*). Of these trees only Tiwas and Babul produce valuable timber and it was agreed that there could be no harm on growing lac extensively on the other species on which it is commonly cultivated in the Central Provinces, provided that lac was not grown in those localities where such tree growth as existed was required for the protection of the soil. The question of the effect of the cultivation of lac on the growth of the host tree was recognized to be

of great importance. No definite information is available as to the number of years lac can be grown on one and the same tree without exhausting it, and what period of rest would be required before the tree was sufficiently recovered to produce more lac. Mr. Lowrie expressed the opinion that the *kusam* trees were not materially injured by the cultivation of lac, provided only small branches were removed with the lac, and there was every reason to believe that lac could be grown on the same tree for a great many years. Experience in other divisions shows that so far as *Palas*, *Ghatol* and *Ber* are concerned, the trees do become exhausted and have to be cut back periodically in order to allow of the formation of new branches on which the insect can develop normally. It was agreed (*Resolution No.* 9) that experiments should be instituted with a view to determining the effect of the cultivation of lac on (1) the quality of the wood, (2) the growth, (3) the longevity and general vitality of the infected trees, with a view to determining the number of years which crops can be expected and the length of the period of rest required by the trees before lac can again be cultivated.

Necessity for taking steps to protect cultivators of lac from theft.

One great practical difficulty to the development of the lac industry in the Central Provinces, was recognized to be the case with which lac could be stolen and the very great difficulty of identifying lac after it had once been removed from the trees. This is a very serious matter and it was unanimously admitted that unless adequate steps were promptly taken to protect cultivators of lac from theft, that it would be impossible to obtain anything like the quantity of lac which the forests could yield, if theft were rendered a difficult and dangerous vocation. The matter is one of such vital importance that it was resolved (*Resolution No.* 10) to move the Local Administration to frame rules for the protection of lac in the forests and in transit under Section 41 of the Indian Forest Act.

Improvement in the manufacture of shellac.

Attention was then drawn to the extremely crude and wasteful methods at present in use for the manufacture of shellac from the lac collected, and it was generally recognized that steps should be taken to improve the existing methods of manufacture. Mr. Caccia stated that Mr. Poorun Singh, Imperial Forest Chemist, had recently made some experiments with regard to the improvement of the existing method of manufacture of shellac, which if they were practicable on a large scale, would revolutionize this industry. The cost of testing Mr. Poorun Singh's discovery was estimated to be less than Rs. 5,000.

The Conference then resolved (*Resolutions Nos.* 10 *and* 11) that the Local Administration should be asked to sanction the establishment of a factory with a view to improving the existing methods of manufacturing shellac, and testing Mr. Poorun Singh's discovery.

Different races of lac and their commercial value.

Mr. A. L. Chatterjee then drew attention to the fact that there appeared to be several races of lac of different commercial values and asked for information on the subject of the possibility of infecting one species of trees with seed lac grown on another species with a view to increasing the value of a low grade lac. His experience was that "seed" lac from *Palas* would grow on *Ber*; but that from *Kusam* would not grow on *Palas*. Mr. Lowrie said that his experience showed that seed lac of *Palas* would grow on *Kusam* but not *vice versâ* and that he thought that the seed lac of a low grade would grow on a tree which produced lac of a higher grade but not *vice versâ*. It was generally admitted that the lac from *Kusam* was much more valuable than that grown on *Ghatol* or *Ber* which in its turn was better than that grown on *Palas*, but that there was no information available as to the comparative commercial values and composition of the different races of lac found in the Central Provinces. It was resolved (*Resolution No.* 13) that a complete list of trees on which lac was found in the Central Provinces should be prepared and that commercial samples of each should be collected and sent to Calcutta for valuation and analysis.

Enemies of the lac insect.

The enemies of the lac insect were then considered and it was recognized that at present very little was known about these and the best methods of combating them. From the information at present available it appears that ants—probably more than one species—were responsible for a great many of the failures in cultivating lac. As

the damage done by the enemies of the lac insect, especially insects, was of considerable importance it was resolved (*Resolution No.* 14) that Divisional Forest Officers be asked to pay special attention to the study of the life history of and damage done by insect pests, and that specimens of all useful and injurious insects together with notes on their life history should be promptly sent to the President of the Imperial Forest Research Institute, with a view to obtaining practical advice as to the best remedial measures. It was generally felt that up to date very little practical help had resulted from references to the Research Institute and that great delay was often experienced in getting a reply to enquiries made.

Cultivation of lac by forest villages.

The discussion ended with a consideration of the practicability of extending the Raipur system cultivation of lac by Forest Villages under departmental control to other divisions. This system has been introduced by Mr. Lowrie, and under his personal care, promises to be most successful. It was recognized that the system had not yet passed out of the experimental stage and that until it had been tried for some years more, it would not be advisable to extend it largely to other divisions. The success or failure of the system depends very much upon getting hold of the right kind of villagers, *i. e.*, men who are accustomed to looking after the lac insect and know its peculiarities and still more on the personal equation of the Divisional Forest Officer. It was resolved (*Resolution No.* 15) that Mr. Lowrie be asked to keep very careful records of the results of the cultivation of lac by Forest Villages in the Raipur Division and that he be asked to place those before the next meeting of the Conference.

RESOLUTIONS PASSED ON MR. LOWRIE'S PAPER.

Resolution No. 7.—That this meeting recognizes that the departmental collection of lac is an extremely complicated problem on account of the careful supervison required and the difficulty of preventing theft, and should consequently only be taken up in compact areas where conditions are suitable. Where lac is found on trees scattered over large areas, contracts for its collection should be given out for a period of years not less than three or more than five. Conditions being entered in the agreement to ensure that the quantity of lac increases rather than decreases.

Resolution No. 8.—That an enquiry should be made as to the merits of the two systems of lac collection at present in force—

(1) Leaving a fixed number of trees for seed and gathering all the lac from the other trees.

(2) Only gathering $\frac{2}{3}$rds of the lac from each infected tree and leaving $\frac{1}{3}$rd seed.

Resolution No. 9.—That an enquiry should be made as to whether the cultivation of lac injuriously affects the tree on which it is grown especially as regards—

(1) The quality of the wood and the growth of the infected trees.

(2) Their longevity and general vitality. The former information is of importance when lac is grown on timber trees, and the latter in order to determine the period of rest required by trees after a crop of lac has been collected; and in localities where lac is grown in thinly stocked areas and it is of the utmost importance that such tree growth as remains should be carefully preserved.

Resolution No. 10.—That in view of the present value and growing importance of lac and myrabolams in the Central Provinces the Local Administration should be approached with a view to framing rules under Section 41 of the Indian Forest Act for the better protection of these minor products in transit.

Resolution No. 11.—That it should be brought to the notice of the Government that the existing methods of lac manufacture leave much to be desired and that it would be advisable to start a Government lac factory in order to improve the existing methods of manufacture.

Resolution No. 12.—That the Conservator of Forests, Southern Circle, should take steps to test the possibility of manufacturing lac on a commercial scale by the improved method of manufacture recently discovered by the Imperial Forest Chemist, Mr. Pooran Singh, that the Local Administration may be asked to sanction the expenditure necessary on this experiment and that the Principal, Forest Research Institute, be asked to allow the Imperial Forest Chemist to help in the matter.

Resolution No. 13.—That Divisional Forest Officers be asked to draw up lists showing the several species of trees on which lac grows, and to collect commercial samples (if possible 32 lbs.) of seed lac for transmission to the Indian Museum (after communication with the Imperial Forest Economist) for analysis and to some broker in Calcutta for report as to their commercial value.

Resolution No. 14.—That the life histories of the insect enemies of lac (especially ants) require further investigation and that specimens of all insect pests found, with notes on their life histories as far as known, should be sent to the President of the Imperial Forest Research Institute, who should be asked to advise as soon as possible what practical remedial measures should be tried.

Resolution No. 15.—That Mr. Lowrie be asked to report on the results of the departmental collection of lac in the Raipur Division at the next Conference as it is considered inadvisable to undertake operations elsewhere until the results of Mr. Lowrie's experiments are known.

SECTION III

(1)—PAPER ON THE MIXED TEAK FOREST OF THE SAUGOR DIVISION, NORTHERN CIRCLE, CENTRAL PROVINCES, AND THEIR TREATMENT.

(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTIONS ADOPTED.

PAPER

ON

THE MIXED TEAK FORESTS OF THE SAUGOR DIVISION, NORTHERN CIRCLE, CENTRAL PROVINCES, AND THEIR TREATMENT

BY

C. M. McCRIE, Esq.,

Deputy Conservator of Forests.

THE MIXED TEAK FOREST AND THEIR TREATMENT.

As most Forest Officers serving in the Central Provinces are more or less familiar with the type of mixed Teak forests dealt with in this paper, a detailed description of the growth is hardly necessary. It is sufficient to say that these forests are of the somewhat unattractive Vindhyan type, Teak forming from 30 to 50 per cent of the crop and seldom rising above a height of 40 feet. As the Saugor peasant generally insists on using Teak, when he can get it for all purposes, and is slow to learn the merits of second class woods such as *Saj*,* *Tinsa*†, and others, it follows that the long-suffering Teak has had much to contend with in the past. Only its marvellous vitality has enabled it to survive the merciless course of lopping and pollarding to which it has been subject from time immemorial. It appears to be a special dispensation of nature that the Teak, which has had the most to endure at the hands of man in the past, has a greater power of resistance than its chief associates. This is clearly seen in many of the fast disappearing village forests in the Saugor District, where the stage preceding utter desolation is often a scrubby and bush-like growth of Teak, all other forest growth having given up the hopeless struggle to cope with village "nistar" as generally understood and practised.

Fortunately the Government forests, though mostly poor in themselves, are many degrees removed from this state of ruin, and contain possibilities for the future which it is the duty of our Department to develop. Mature Teak are generally distorted by frequent lopping, and even young poles have not escaped the same fate. Vigorous young coppice shoots of Teak unfortunately find favour in the eyes of the Saugor peasant as being efficient substitutes for bamboos, so that a really sound straight Teak tree of over two feet in girth is something of a rarity. Seedlings are generally conspicuous by their absence, and in many of the forests, it must be admitted, that regeneration by seed is almost entirely wanting, or proceeds with extreme difficulty and slowness.

The method of treatment prescribed for these forests is coppice with standards, which meets present requirements and calls for the exercise of comparatively little skill on the part of a mostly untrained staff. For the present, coppice reproduction of nearly all species may be relied on with certainty, and the ground is re-covered as soon as possible after the felling—a notable advantage on the arid slopes and frosty hollows with which the Saugor District abounds. There can be little doubt, however, that sooner or later the management of these forests will present problems which are apt to be overlooked in the simplicity of the present working. It is a question for careful study how the continuance of the forests is to be assured. We at present know little or nothing as to the longevity of coppiced stools of Teak and other local species. Great stress has been laid upon shoots which issue on or near the ground level developing root systems of their own distinct from that of the mother tree. The extent to which they actually do so appears somewhat uncertain, but in any case it seems only too clear that such shoots can never acquire the characteristics and expectation of life of seedling trees. This is made evident by the abnormally early age at which coppice shoots flower and seed. I have found Teak coppice poles 10 years old and 25 feet high flowering profusely and yielding apparently healthy seed, and it seems to be a law in both animal and vegetable kingdoms that precocity in this respect means early maturity and a comparatively short term of life. No doubt the vitality of Teak stools is great, as is shown by the manner in which they continue to produce shoots year after year on annually cleared boundaries and fire lines, but they cannot last for ever, and it is possible that, even with a comparatively long coppice rotation, they may fail us sooner than we think. The amputation at stated intervals of the whole of the assimilating organs, which have to be hurriedly replaced by the root system, must be a strain on the latter which can hardly fail to reduce its longevity. It is clear, therefore, that if these forests are to be managed as coppice in perpetuity, we

* Terminalia tomentosa. † Ougeinia dalbergioides.

must look to the provision of an adequate supply of seedling stems to replace the present stock of stools when these are exhausted.

The paucity of natural reproduction from seed already referred to is thus an extremely serious matter, and its causes appear to me to require even more careful enquiry, observation, and experiment than they have yet received. In the meantime we must provide for the future as best we can by the reservation of a good proportion of healthy standards, whereby we encourage natural reproduction from seed if we cannot actually ensure it. Doubt has been cast upon the fertility of the seed borne by Teak coppice shoots, and I understand that this is at present under experiment. There is no apparent reason why a fair proportion of the seed yielded by coppice shoots of moderate age should not be fertile, but if it is found to be otherwise then the paucity of Teak seedlings in these forests will be at once explained, since there are few Teak now standing which have not been more or less irregularly coppiced at some period in their life history. The result of the experiment with coppice seed will be awaited with interest by all who are concerned with the management of such forests. Should it appear that this seed is useless, or nearly so, there will be a strong case for increasing the number of standards (at present 50 per acre in Saugor) and, where natural means fail, for further experiments in the sowing of healthy seed *in situ*, as is done in many European coppice forests.

Coming now to the fellings in these mixed Teak forests, distinction may be drawn between—

(i) Regular coppice fellings.
(ii) Improvement fellings.

The regular coppice fellings are on a rotation of 30 years. About 50 standards per acre are marked for reservation during the previous hot weather and rains, and the coupes are, as far as possible, sold standing to lessees. The stereotyped form of agreement with lessees makes the latter undertake to fell everything in the coupe exclusive of the marked standards, fruit and lac-bearing trees, bamboos, and saplings below a certain girth. Where fuel is marketable this thorough clearing of the coupe can be, and has been, insisted on with advantage. But in the remoter Felling Series where fuel is unsaleable, or is saleable only in small quantities, it is found necessary to be content for the present with something short of complete coppicing over the whole area. Rigid insistence on the coppicing by lessees of large quantities of unsaleable material would only result in the discouragement of the latter, and in the indefinite postponement of any form of regular working. To meet cases where the demand on the remoter Felling Series is only beginning to develop, lessees of such coupes are permitted to practice a sort of "modified coppice" or "selection coppice" felling. They are under agreement to coppice *all* unreserved trees of such species as are saleable locally as timber, and to cut back any trees or inferior species which may be injuring more valuable growth, or which may be likely to suppress shoots from the stools of the better species. The timber species which the lessee is compelled to coppice vary in different Felling Series. In the remoter series it may be Teak alone, and in others Teak, *Saj* and a few of the other second class woods. The cutting back of these is the first operation, the area is inspected by the Range Officer who marks with a broad blaze the trees of inferior species which must be removed for sylvicultural reasons. Any tendency on the part of the lessee to shirk this stage of the work after he has extracted the plums can easily be met by enforcing the penal clauses of his agreement bond, which provide adequate penalties for any breach of the conditions attaching to the lease. As a matter of fact it is not found that the removal of such inferior species as have to fall for sylvicultural reasons is a very formidable undertaking in these thinly-stocked forests. The rapid growth of teak coppice during the first few years of its life, and the remarkable power of the shoots of pushing their way through overhead cover, enable them to succeed without any assistance in the great majority of cases. In actual practice I have found that the shoots are safe so long as a Teak stump has nothing directly above it. They can stand plenty of side shade during early life and can easily hold their own if they have light directly over head. In a few years they are practically on a level with the rest of the crop in these thin and stunted forests.

This form of "selection coppice" felling may be objected to on the score that it is not a regular sylvicultural system, and it is true that it does not find a place in Doctor Schlich's Manual. But under the conditions with which we have to deal, we generally have to be content with something short of the ideal, and all that is claimed for the above is that it is a serviceable makeshift. It supplies and fosters the present limited demand on the remote coupes to which it is applied, and at the same time effects a real improvement in the forest crop by replacing all undesirable and deteriorating stems of the better species with healthy coppice growth. Undoubtedly if the text book be rigidly adhered to, everything but the standards should be cut, but the only result of this would be to discourage any form of regular working for the present, and perhaps to stop it altogether. The coppice system can be reduced to an absurdity by slavish adherence to rules when these are applied by untrained subordinates, and I have actually seen Thuar (*Euphorbia neriifolia*), which produces no coppice shoots, cut back at considerable expense on a stony slope where it was almost the only soil covering! But even when inferior species coppice readily, as most of them do, it does not appear that any useful purpose is served by coppicing them when they are interfering with nothing of greater value, and, being quite unsaleable, would only remain to rot on the ground or increase the intensity of forest fires. Species which are only used as fuel are little more suitable for that purpose in the shape of straight coppice poles than in the forms in which they naturally occur in these forests, and there is no sylvicultural or economic reason why, under present conditions, money and labour should be expended on growing fuel-yielding species in one shape rather than in another. If the felling is properly supervised, their retention can do no harm, and may well be beneficial in keeping the soil covered, and in protecting the shoots of the better species against the effects of frost and drought where these dangers are to be feared.

For some years past a series of improvement fellings has been carried out departmentally in the Saugor Division. These fellings have been chiefly confined to such coupes of past years as have remained unworked, or have been partially worked by license-holders or lessees who have cut only the best of the unreserved poles. These improvement fellings are somewhat similar to the "selection coppice" described above, consisting of the cutting back of all badly shaped and sickly specimens of the timber yielding species, which may be Teak only or may include some of the second class woods according to local conditions. At the same time all inferior species suppressing, or likely to suppress, more valuable growth are cut out or girdled. The operation is one that does not call for a high degree of skill, and it is found that a fairly intelligent Forest Guard, after some instruction, can direct it efficiently under the general supervision of the Range Officer and his assistant. Thus no expenses is incurred on a preliminary marking of the trees for felling, as these are chosen by the Forest Guard and pointed out by him to the labourers as the work progresses. The ordinary programme of improvement fellings for the year 1907-08 was more than doubled in the Saugor Division as a measure of Famine relief. In all an area of about 2,320 acres was treated at an average cost of about 13 annas 8 pies per acre. The number of trees felled per acre averaged 35, the cost of the work being thus a little under 5 pies per tree. From these figures some estimate may be framed of the rich return which may fairly be expected from the comparatively trifling expenditure incurred. The trees felled (mostly Teak) had no future before them, and were likely to deteriorate rather than increase in value. The stools may fairly be expected to produce on an average at least one good coppice shoot a piece, and these shoots in another 30 years will be worth not less than 8 annas each as they stand—probably far more, as the long threatened timber famine should by that time have declared itself. The cost of felling, with compound interest at 4 per cent, will by that time have amounted to about 1 anna 4 pies per stool, so that, at a conservative estimate, the net return will be at least $6\frac{1}{2}$ annas per tree, or in round figures Rs. 33,000 on the operations of 1907-08, which cost only Rs. 1,990. These figures are admittedly not much more than guess work, but they have a sufficient basis of fact to support the Forest Department in asking for funds to extend such felling even in places where their yield is at present unsaleable and where they bring in no immediate return.

I shall conclude with a few words as to the season of the fellings and the mode of executing them. Experiments, which I believe are confined to the Northern Circle, have been in progress for some time to ascertain whether coppice reproduction is affected in any way by the season at which the mother trees are felled. No results have as yet been published, but so far as my own observations go, I believe it to be true that the proportion of stools which fail to yield shoots is greater among trees felled during the rains (July to October) than during the remaining 8 months of the year. This is only what might be expected, as it is generally admitted as an axiom that fellings should proceed when, in common parlance, "the sap is down," and that preferably they should be completed at least a fortnight before vegetative activity commences, so as to allow the root stools a short interval to recover from the shock which it has sustained. The point is one of some importance in these forests, where we depend so largly on coppice reproduction, and fellings are now stopped in the Saugor Division from July to October. I believe that in some parts of the Provinces it is still the custom to coppice in the rains, the timber obtained from such fellings being held to be more durable than that cut at other seasons, and it would be interesting to hear what have been the sylvicultural results of such fellings as compared with those executed at what is theoretically a more suitable time.

As to the mode of coppicing, it is possible that too much stress has been laid in the past upon the trimming of the stools with smooth surface sloping from the centre. There is a regular staff of forest labourers near most of the Saugor Felling Series who have been carefully trained to this work year after year, and many of whom are now inclined to carry the trimming process too far. When employed on a daily wage, a man will sit chipping a stool till the surface almost suggests the use of a jack plane and sand-paper. It seems likely that, so long as the stems are felled at ground level, refinements of trimming are wasted labour.

Greater care should, however, be taken with trees which are approaching the limit of coppicing age and whose coppicing power is doubtful. It is noticed that in such stems the bark at the ground level readily dries up and separates from the wood, and that when this happens all hope of coppice reproduction is at an end. The greatest care is therefore necessary to avoid any injury in coppicing which might increase the danger of such separation, and the chances of success may be augmented by careful trimming, which is hardly necessary in ordinary cases.

DISCUSSION ON MR. McCRIE'S PAPER.

Mr McCrie opened the discussion on the correct treatment of the Mixed Teak Forests of the Central Provinces by briefly describing the treatment to which the forests of this type in the Saugor Division were subjected and invited discussion (1) on the subject of the longevity of the teak stools, (2) the correct treatment of forests where there was no demand, at present, for the inferior species which frequently constituted by far the larger part of the existing crop, (3) the effect of the season of year at which the stools were cut over on the resulting coppice shoots and (4) the reason why many of the coppice shoots produced, remained recumbent and would not grow erect.

The Conference first discussed the proper method of working the Mixed Teak Forests of the Central Provinces, the nature of which was briefly described in Mr. McCrie's paper and is familiar to all Forest Officers in these Provinces. It was unanimously agreed that where there was a good demand for fuel, the coppice with standards silvicultural system was the proper one to adopt; that no hard-and-fast rule with regard to the number of standards to be left per acre could be laid down, as this must depend upon the factors of the locality; the composition of the mixture of the species of which the forest is composed; and the nature of the market. It was generally agreed that pure teak forests were a mistake, that it was very necessary to maintain a mixture of species, and that where there was a tendency for the forest to become pure teak, that standards of the more valuable of the inferior species associated with it should be carefully preserved.

The question of the treatment of forests in localities where only Teak and a few of the better of the inferior species can be sold was admitted to be more difficult. The coppice with standards system in its entirety could not be applied to these woods, on account of the great expense the coppicing of all trees left by the purchaser of the coupe would involve, and that some modification was therefore necessary. It was generally agreed that, all that could be done at present was to make a "partial" coppice felling, followed by a silvicultural operation with the object of encouraging the growth of the more valuable trees in the mixed crop. The existing crop in this type of forest is so incomplete, that there is practically no danger of the more valuable species being injured by the inferior species associated with them, as in addition to the thinness of the crop on the areas to be worked, the inferior species grow more slowly than Teak, as it is quite able of making its way through a fairly dense cover, and where necessary, it can be protected from its associates in the cleanings and thinnings which will be made when necessary.

The different methods of executing "partial coppice" fellings were then considered. It was agreed that the trees of the more valuable species which could be cut, should be marked, whereas in the case of inferior species, those stems which were to be kept, should be marked with rings of paint or tar. This procedure is practicable as the valuable species are numerically few; and as the demand for the inferior species is admittedly small, it is only necessary to mark those trees which should be kept, and allow the purchaser to remove any of the unmarked trees that he may choose.

The coupes marked during the working season will be sold by auction in the following rains and the purchaser given the whole of the next working season to work out the coupes. Where the coupes are small they should be given to the end of March to extract the produce bought, so that the silvicultural operation which follows the exploitation may be made before the rains break, and a year's growth, so far as the coppice shoots are concerned, saved. As a rule this silvicultural operation should be done under departmental supervision and the stems cut roughly stacked, so as to allow of their removal by purchasers during the next working season. It should be noted that the rainfall is light in the Central Provinces, and experience has shown that fuel does not materially deterioate during that period of the year; on the contrary, in Berar and some parts of the Central Provinces, purchasers will not buy green fuel, but readily extract it after the rains, when it is dry.

In more advanced parts of the Province it may be found practicable to get the contractor to execute the silvicultural operation, under departmental supervision at the same time as he works over the coupe. This procedure should be followed wherever possible without injury to the existing crop. The result of the "partial coppice felling" will be (1) removal of the worst part of the principal species in the forest and their replacement by straight coppice shoots capable of producing timber in the next rotation and (2) a marked increase in the number of the valuable species in the mixed crop. The markings will be made, not to produce revenue but to improve the composition of the existing crop and to increase the value of the species suitable for timber. The conclusions arrived at are embodied in *Resolution No.* 16.

The question of the longevity of Teak stools and their power to produce vigorous coppice shoots was then taken up. Mr. Caccia informed the meeting that this question is under the consideration of the Imperial Forest Botanist, and that he hoped soon to publish the result of his investigations. Many Forest Officers reported that their investigations on this subject led them to believe that Teak, if properly treated, can be coppiced practically for ever, as the coppice shoots form new root systems for themselves, and that in consequence the forests are always full of young healthy stools capable of producing strong vigorous coppice shoots. It was unanimously agreed that it is necessary that the shoots should be carefully coppiced flush with ground to ensure that the coppice stools produced should at once start developing a root system of their own and that although it was necessary that the stools should be very carefully cut over, ultra refinements in trimming the stools, though a mistake in the right direction, were not necessary. Mr. Fisher spoke very strongly on the necessity for the careful trimming of Teak stools so as to prevent the possibility of the inclusion of any wood of the old stool —a common cause of unsoundness—in the resulting stool shoots and deprecated any tendency to slur over the coppicing of the stools.

No definite information was forthcoming on the reason why Teak stools in certain localities produced only recumbent shoots which never became erect or developed into true coppice shoots. Mr. Bartlett stated that in the Melghat Division, he had noticed, that, in the case of some hot dry slopes, covered with poorly grown crooked stems which had been coppiced, that the resulting shoots crooked and weak like their ancestors, and that he had come to the conclusion that the locality was unsuitable for teak and that straight coppice shoots could never be expected. This reason does not explain other cases reported from other divisions and the question is one which requires further investigation. *Resolution No.* 17 was then framed, put to the meeting and passed.

The next point to be considered was the effect of the season of the year at which the stools were cut over, on the growth of the resulting coppice stools. Sample plots were made in several divisions with a view to determining which was the best season of the year for coppicing trees. From the available records it appears that in the Central Provinces the months of August and September are the least favourable for coppicing; that there is very little difference between the months of October to the break of rains, usually the end of June. Mr. Fisher, informed the meeting that in the Thana district in Bombay, it had been found that stools cut in the month of September produced much stronger coppice shoots than those cut in the months of March and April. The present practice of cutting over trees during the working season, *i. e*, between the end of the rains (October) and the end of the hot weather (June) therefore would seem in the Thana district, Bombay, to require no modification. *Resolution No.* 18 was then put to the meeting and passed.

The Conference then proceeded to discuss the reasons for the admitted unsatisfactory natural regeneration of Teak in some parts of the Central Provinces. This has been attributed to several causes, the principal of which in the Central Provinces are the absence of seed bearers, the dense weed growth and the unsuitable condition of the soil for the germination of the seed.

In many parts of the Central Provinces the majority of the existing crop of Teak has, there is every reason to believe, originated from coppice shoots, and the question has been raised as to whether the seed produced by coppice shoots is fertile or not. The evidence adduced by Central Provinces Forest Officers is very strongly in favour of teak seed from coppice shoots being fertile. In Berar particularly, seedlings are fairly common in woods which have been coppiced from

time immemorial and here, at any rate, there can be no doubt that the seedlings must have originated from coppice shoots and not seedling trees.

Recent observations of many forest officers have also conclusively proved that natural seedlings are not so uncommon as was formerly thought. These seedlings are easily mistaken by casual observers for stool shoots, as they resemble the latter so closely, that it is necessary to uncover the root system before the true origin of the plant can be determined. In a hot dry climate like that of the Central Provinces seedlings of Teak, almost without exception, die back during the hot weather. All the seedlings which die back do not die absolutely, but some of them send out another shoot after the rains break. The majority of these shoots die back before the next rains, but before dying strengthen the delicate root system of the seedlings. This dying back goes on until the root is sufficiently thickened to allow of a strong shoot being sent up which does not die back during the hot weather; the seedling is then established, and will under normal conditions develop into a tree. It would therefore appear to be established that the absence of natural regeneration referred to, is not always due to absence of fertile seed.

The dense growth of grass and other weed growth in the open type of forest in the Central Provinces in which Teak is found, is undoubtedly one of the principal causes for the rarity of Teak seedlings. The majority of the seeds are prevented from reaching the mineral soil and those which do germinate are killed for want of light. Teak seedlings are not found in larger numbers in areas regularly burnt than in fire protected areas, so their absence cannot be ascribed to successful fire protection. In some parts of Berar, Teak seedlings are commonly found in the State pasture lands (forests of Class C, Division I) which are heavily grazed but not burnt, which points to the injurious effect of weed growth. In the Betul and Melghat Divisions, particularly, in areas which have been practically closed to grazing and successfully protected from fire for a number of years, natural regeneration is very satisfactory. Successful fire protection results in the grass becoming thinner and thinner and eventually in the mineral soil becoming exposed; the root system of the germinating seeds then reach the mineral soil, and seedlings appear and grow up through the thin growth of grass which is found on the area.

Heavy grazing and fire result in the hardening and impoverishing of the soil, thus rendering it unsuitable for the germination of such seeds as fall on it. In the Teak areas in some parts of Burma it is believed by some Forest Officers that fire-protection prevents natural regeneration of Teak, but so far as our experience goes at present this is not true of the Central Provinces. At the end of the discussion it was resolved (*Resolution No.* 19) that experiments should be made to see if natural regeneration can be induced by:—

(1) ploughing and wounding the soil under seed bearers,

(2) keeping the ground under seed bearers free of weed growth, especiallv grass,

(3) burning the grass and undergrowth around seed bearers.

The last point discussed was the height above the ground that stools should be cut in order to develop strong coppice shoots. Mr. Donald stated that in the Chanda Division Contractors invariably left the stools about 3 inches above the ground, that he had noticed that the shoots from these stools were stronger than those cut flush with the ground, and that he had found, within certain limits, the more carelessly the stools were cut over, the better were the resulting stools shoots. The general opinion of the Conference was strongly pronounced against the procedure followed in South Chanda. It considered (*Resolution No.* 20) that the stools should be cut over, flush with the ground, so that the stool shoots developed should form root systems of their own and should not be dependent on the mother stool for nourishment longer than was absolutely necessary; and that only in places where the cutting the stools flush with the ground does not result in the development of good shoots, should the stem be cut other than at the level of the ground.

In the case of some species in which the bark separates quickly from the wood, it may be found necessary to cut the stems a little above the ground, to ensure stool shoots being developed at the surface of the ground; but this should only be done, when cutting flush with the ground is not successful, as the resulting stump cannot be overgrown by the coppice shoots and these latter must include a portion of the old shoot thus rendering them liable to unsoundness.

RESOLUTIONS PASSED ON MR. MCCRIE'S PAPER.

Resolution No. 16.—That the mixed Teak pole forests of the Central Provinces, where the demand is sufficient, should be worked by the Coppice with Standard's system in its entirety; the number of standards to be left depending upon the factors of the locality. Where the demand is insufficient a "partial coppice" felling should be made, followed by a departmental silvicultural operation, in accordance with definite rules, depending upon the factors of the locality, with the object of the improving of the existing growing stock. Partial coppice fellings in the Central Provinces are recognized as being admissible even if the subsequent silvicultural operations are not completely carried out. The forests are poorly stocked and no other system of working is at present possible

Resolution No. 17.—That, as a rule, the reproductive power of Teak coppice shoots in the Central Provinces is, so far as is known at present, exceedingly good and that under normal conditions there is no reason why the mixed Teak pole forests of the Central Provinces should not be worked by this system indefinitely. It is recognized, that it is essential to the success of this system, that the stools should be cut flush with the ground and carefully trimmed, especially around the periphery. That as the question of the longevity of Teak coppice stool shoots and season of felling, with special reference to the Central Provinces Forests, is under investigation by the Forest Botanist at the Imperial Forest Research Institute, the further consideration of the subject should be postponed until the results of his investigations have been published. His attention should be invited to the advisability of investigating the relation of the longevity of coppice shoots to the size, age and soundness of the stools coppiced, and to the reason of the production of the imperfectly lignified teak coppice shoots referred to by Mr. McCrie, about which nothing is known at present.

Resolution No. 18.—That in India the time of coppicing the teak does not appear to materially affect the production of coppice shoots, and that so far as experiments have been made at present, August and September are the least favourable months for coppicing in the Central Provinces.

Resolution No. 19.—That in view of the unsatisfactory natural regeneration of teak in parts of the Central Provinces, Divisional Forest Officers should be asked to undertake experiments to see if natural regeneration cannot be induced by:—

(1) ploughing or wounding the soil under seed bearers,
(2) keeping the ground free of weed growth, especially grass,
(3) burning the grass and undergrowth.

The areas experimented on should be fenced, and all observations made, carefully recorded.

Resolution No. 20.—That investigations should be made with regard to the best method of coppicing trees in places where cutting flush with the ground does not appear to give successful results.

SECTION IV

(1)—PAPER ON THE ALLAPILI MONORAIL TRAMWAY, NOTES ON THE MONORAIL TRAMWAY AT THE JUBBULPORE GUN FACTORY, AND THE SHIVARAJPUR MONORAIL TRAMWAY.

(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTIONS ADOPTED.

PAPER

ON

THE ALLAPILLI MONORAIL TRAMWAY, AND NOTES ON THE MONORAIL TRAMWAY AT THE JUBBULPORE GUN FACTORY, AND THE SHIVARAJPUR MONORAIL TRAMWAY

BY

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MONORAIL TRAMWAYS.

The Allapili Monorail Tramway.

Introduction.

The Allapilli forests lie 72 miles south-east of Chanda and an average distance of about 9 miles from the Pranhita River. They were bought from the Zamindar of Ahiri in 1873. Ten years later an additional area was purchased in order to consolidate the Government Estate. The quality of the locality is excellent and favourable for the growth of large timber; but the existing stock is very unsound and had been severely cut about before the purchase was effected.

Until quite recently Warora was the nearest railway station and most of the timber was carted 102 miles to a depôt there. In order to avoid carting any wastage, and to supply sleepers to railway companies, saw mills were erected at Allapilli in the early seventies. Transport to the mills from the forest and afterwards to Warora Depôt was carried out by means of bullock carts. The country is fairly level, except in the hills which rise abruptly from the plain, and is eminently suitable for development by means of a tramway. At probably the most unfavourable period for the success of the scheme, because the fellings were drawing nearer and nearer to the mills and freight becomes relatively more expensive the shorter the lead, proposals for the introduction of a more up to date and cheaper system of transport from the forests to the mills, than by country carts were called for by the Conservator of the Circle. This was in 1902.

The local officers were in favour of a monorail as being less expensive and giving less trouble to shift about than a double line, and estimates were called for accordingly. As the working for the next few years lay in areas within a radius of 4 miles from Allapilli, a corresponding length of line was fixed on.

2. A firm submitted the following estimate:—

Estimate for a monorail portable tramway (*Caillet's*).

Estimate and actual cost of the line.

Four miles of flat-footed steel rails, 12 lbs. per yard, complete with scabbard fish plates, and six large sole plates, to each 16′ 6″ rail delivered at Warora Railway station, including cost of four crossings and four portable ramps:—

	Rs.	Rs.
at Rs. 3,500 per mile	14,000	
10 special bogie trucks to carry 25 feet-logs at Rs. 350 each.	3,500	
		17,500
The Divisional Forest Officer estimated:—		
(i) The carriage from Warora to Allapilli (102 miles) at Rs. 17 per ton.	1,190	
(ii) The extra cost of points, sidings and breaks for trucks at Rs. 600.	600	
(iii) The cost of laying on an existing cart truck, levelling and bridging at Rs. 350 per mile.	1,400	
		3,190
		20,690
What was actually bought was:—		
4 miles of Caillet's patent monorail tramway rails, 14 lbs., inclusive of points and crossings consisting of 1,271 steel flanged rails 16′ 6″ × 14 lbs.		
1,272 pairs, fish plates.		
6,400 rail chairs.		
12,350 bolts and nuts	10,180	
6 special bogie trucks to carry logs 25 feet long at Rs. 350 each.	2,100	
1 jack screw	34	
12 additional wheels and steel channel iron ...	74	
Royalty on Ewing's patent balance wheel (subsequently affixed).	900	
		13,288
Carriage from Bombay to Allapilli	2,322	
Laying of four miles	594	
		2,916
Or Rs. 4,081 per mile.		16,204

The line was laid during December 1902.

3. It is instructive to compare the original estimate by the firm and the figure to which they eventually agreed. They estimated Rs. 14,000 for 12 lbs. rails at Warora, add cartage to Allapilli (Rs. 1,190) and the total is Rs. 15,190. They actually supplied 14 lbs. rails F. O. R., Bombay, at Rs. 10,180 and carriage to Allapilli from Bombay amounted to Rs. 2,322; or a total of Rs. 12,500, a reduction of Rs. 2,688, although the rails were 2 lbs. heavier equivalent to Rs. 25,332, so the total 'softening' of the original estimate was Rs. 4,854 or 32 per cent.

They offered to lay the line for Rs. 300 per mile or a total of Rs. 1,200. The actual cost of the work done departmently was Rs. 594.

The local officers were in favour of trucks on the Ewing system, *i. e.*, with a balance wheel. The firm considered Caillet's to be the more suitable and built them accordingly. The first trials showed that the Caillet system was impracticable and the trucks had to be converted into the Ewing pattern. Expert advice is most essential, but it should be obtained from an independent and unbiassed source, and the first quotation is not necessarily the lowest.

5. From the papers available the question of a double line does not appear to have been sufficiently carefully, if at all, considered.

General description of the plant.

6. The monorail tramway as purchased consisted of a single line of rail, steadied by iron sole plates 10″ × 5′ affixed every three feet, laid flat along a roughly levelled track without ballast and without sleepers.

The laying was simplicity itself and cost only Rs. 150 per mile. No skilled labour was required and curves had not to be laid out with the mathematical correctness required by a double line.

7. The trucks (Plate I) were double bogies connected by a heavy channel iron frame and provided with flat shoes projecting down almost to the ground, at either side of each bogie, to bear the weight of the truck when not in an upright position, and to prevent it coming right over on to the frame. The wheels, two sets, placed tandemwise, were double flanged and sat very loosely on the rail. On the top of the frame were two upward curved pieces of channel iron, one over each bogie, to support the logs. From one side of the truck came a flattish S-curved iron to the end of which was attached the bullock yoke. It was presumed by the Engineer who designed this attachment that the bullocks would be able to bear the strain of balancing the load in addition to dragging it. Vain presumption! The unfortunate animals when the truck tilted away from them were hoisted into the air by their neck ropes and nearly strangled, a position however that compared favourably with that in which they found themselves when the load tilted towards them. Pinned to the ground by their yokes, and by the S-shaped iron with a 1½ ton load to keep them there, their state was indeed serious and painful, until the united efforts of several men succeeded in unloading part of the burden and in restoring the equilibrium of the truck.

A more impracticable method of traction, side traction at that, could scarcely have been devised.

8. The local officers at once hit on the device of affixing a large cartwheel (Plate II) to each bogie, which would bear part of the weight of the load, in theory 10 per cent, and practically converting the monorail truck into a hybrid—a cross between a cart and a truck with four wheels tandem on the rail and two wheels tandem on the road.

The lateral yoke attachment was done away with, a pole with a yoke was fixed to a ring in front, and the bullocks had the load behind them instead of along side, or on the top of them. The trucks were a little less handy than before, as they could only now be loaded from one side, and of course required more room and a prepared track for the cart wheels; but they were

innocuous. These balance wheels were found to have been patented by Charles Ewing and a royalty of Rs. 150 per truck had to be paid.

9. In 1904 the cast iron wheels originally supplied began to give a lot of trouble. Owing to the weight of the load falling partly on the balance wheels and partly on the bogies, in proportions varying greatly with the inequalities in the road and to careless loading. The centre of gravity was well to the balance wheel side of the line, and the pole being attached to the middle of the end of the frame, there was always a lot of friction that should have been unnecessary. The question of converting the line into a double tramway was then raised; but the Divisional Forest Officer proposed that it should be given another trial with wheels having the treads of chilled steel instead of cast iron. This innovation was adopted and has proved to be very successful. The line has worked very satisfactorily ever since.

10. In November 1905 it was relaid on a new alignment in order to tap a fresh group of coupes. The removal, the making of the fresh road with bridges and cuttings and the laying down of the line, cost Rs. 400 or Rs. 100 per mile.

11. The bridges over small nalas are made of 'furrahs', or the side pieces of logs, supported on stout poles placed transversely to the length of the road, supported by forked uprights sunk into the bank or bed of the stream. Dry stone buttresses completed a very simple and cheap type of bridge that is strong and lasting. The larger nalas were negotiated by temporary Irish bridges, the bottom layer was composed of large logs placed parallel to the banks at intervals of 3 feet. This allows of sufficient waterway for the small flow of water in such streams, in November or after a heavy shower in the cold weather. On the top of the logs are placed furrahs and then as much earth and murram as is necessary to bring the road up to the required level. Just before the rains each year the timber is removed and placed in safety on the bank.

12. Except on the bridges, where murram is used, earth is used for packing and for the cart wheel track. The present alignment lies for the greater part through black cotton, and a track on either side of the rail is kept in rough repair as there is cart traffic over the road and it is convenient to load some trucks on one side and some on the other. Bullocks are not strong enough to draw a loaded truck. A good pair of buffaloes can draw $1\frac{1}{2}$ tons $1\frac{1}{4}$—$1\frac{1}{2}$ miles per hour. The gradients are light. For a short distance up one nala bank there is a rise of 1 in 17, but this is the only severe one in the whole distance.

Traffic and capability of the line.

13. The traffic consisted of teak logs up to about 1,300 tons over an average distance of 3 miles, or 3,900, say with fuel 4,000, ton miles. The capability of the line, *i. e.*, the maximum quantity of material that the line could carry in the year may be calculated as follows:—The line could be open from November 1st to the 15th of June or $7\frac{1}{2}$ months; allowing for holidays, say 6 months or 180 actual working days. Each of the 6 trucks could make one trip over the 4 miles carrying $1\frac{1}{2}$ tons and return empty again in one day. That is the 6 trucks would carry $6 \times 1\frac{1}{2} \times 4 = 36$ ton miles per day or in 180 days, a working year, the line could carry 6,480 ton miles.

Financial aspect of the line.

14. During the first four years that the line was working 287,389 cubic feet or 5,748 tons or 4,311 ton miles per annum (nearly double the normal quantity was extracted during the first two years owing to short removals in previous years) were brought by the monorail to the mills at a cost of Rs. 22,465 or Rs. $\frac{22,465}{5,748} \times 3 =$ Re. 1-4-10 per ton mile.

Had carts been employed the total cost would have been Rs. 32,930 or Rs. $\frac{32,930}{5,748} \times 3 =$ Re. 1-14-7 per ton mile. These figures are given in detail below and include the cost of bringing from the forest to the rail, loading, unloading, depreciation (not interest, which if calculated at $3\frac{1}{2}$ per cent on the capital would increase the rate per ton mile by Re. 0-2-1 or to Rs. 1-5-11) on all stock, live or dead, employed.

The traffic being so slight and the distance so short, accounts for the high rate :—

	1903-04.	1904-05.	1905-06.	1906-07.	Total
	Rs.	Rs.	Rs.	Rs.	Rs.
Pay of coolies	1,606	1,450	330	405	3,800
Repairs and up-keep of monorail including laying down tramway on new lines, royatly, etc.	357	1,185	494	148	2,184
Feed and keep of elephants and cattle ...	2,971	2,998	1,733	2,437	10,139
Establishment ...	156	158	136	144	594
Depreciation at 10 per cent on capital cost...	1,612	1,450	1,305	1,521	5,888
10 per cent value of elephants and cattle ...	200	175	120	240	735
Total Expenditure ...	6,902	7,425	4,118	8,495	23,340
Less cost of other works ...	...	...	...	875	875
Net cost by monorail ...	6,902	7,425	4,118	4,020	22,465
	Cft.	Cft.	Cft.	Cft.	Cft.
Total number of cubic feet landed at the mills by the monorail.	98,242	127,070	25,418	36,659	287,389
	Rs.	Rs.	Rs.	Rs.	Rs.
Cost of above if carried otherwise at Re. 0-1-10 per c. f. (paragraph 79 of A. R. for 1903-04).	11,257	14,560	2,913	4,200	32,930
Profit on working of monorail ...	...	...	...	....	10,465

Points in connection with the working of the line.

15. The facility with which the line can be taken up and laid down is undoubtedly its chief advantage. Only a minimum of skilled labour is required, and the track need not be specially prepared beyond making the road for the wheel, level with the bottom of the rails.

Except in moist place no sleepers were used ; the sole plates rested directly on the ground.

16. In the exploitation of coupes, the line has been invaluable, as it can be laid to wherever large trees are numerous. Elephants could then drag the logs direct to the rail head, without any carting having to be done at all.

17. In order to reduce friction the wheel tread should be twice the breadth of the rail head. Also the drawing pole should be fixed a little to the balance wheel side of the centre of the bogie, and a murram or metal track should be made for the balance wheels.

18. The trucks, primarily intended to carry logs, have also been used for fuel. About three cart loads of fuel go to one truck.

19. The very clumsy and unwieldly nature of the frame with the balance wheel attachment compares unfavourably with the light double rail bogies now obtainable for this class of work.

Further, the double rail requires no more pucca road than the existing pattern of monorail, with its two large balance wheels. A light double line for bullock and hand traction recently put down in Assam by Mr. Perrie, Deputy Conservator of Forests, cost Rs. 6,000 per mile complete with rolling stock and inclusive of carriage and laying.

The difference in the cost of the monorail, *viz.*, Rs. 1,850 per mile, would probably be saved after a year or so by the increased carrying power and lesser traction. If on a double line, one pair of buffaloes could carry 2½ tons against 1½ on the monorail, the additional expenditure would be more than compensated.

20. To summarise, disadvantages of the monorail are :—

(i) It is dangerous and impracticable for unskilled labour without the use of the balance wheel.

(ii) With the balance wheel it can be loaded only from one side.

(iii) The large amount of friction.

(iv) The centre of the bogie, to which the pole of the dragging yoke is fixed, is not in the axis of the centre of gravity, which lies between the bogie wheels and the balance wheel, and this causes additional friction between the wheel flanges and the rail, besides putting considerable strain on the bearings and on the line itself.

(v) The frequency of derailments.

(vi) Lower carrying power compared to a double rail.

(vii) If it is necessary to load some trucks on one side and some on another, an additional track must be levelled for the balance wheel on the other side.

(viii) Owing to (iv) it is difficult to make trains of the trucks unless the balance wheels are on opposite sides, when two levelled tracks as in (vii) would be required.

21. The advantages are :—

(i) Cheapness.

(ii) Portability—easy to take up and to lay down.

(iii) Can go round sharper curves than a double rail, though with the addition of the balance wheels this difference is not so marked.

(iv) The actual line interferes very little with other traffic.

(v) No skilled labour is required.

22. Taking everything into consideration a portable 10 or 12 lbs. double rail would probably have been the more satisfactory and in the end cheaper. Further if a tramway is to be laid a monorail means only half a tramway and half a cart. A heavier rail, 14 lbs, at least, is required than for a double line for the same traffic. For a double line, sleepers are required, but the Forest Department can obtain these very cheaply and on the spot. One man can barely push one empty monorail truck of a carying capacity of 1½ tons. A child could push two double line bogies of twice the capacity with ease.

23. The Allapilli tramway scheme was for a very small amount of traffic and the line has been successful and has paid its way. I append, however, a note on a monorail tramway 20 miles long put down by a manganese company and worked to its utmost capacity. Had a double line been laid originally the agent estimated he would have saved his company a matter of Rs. 70,000 during the two years that the line had been working. Another note, by Major Edgehill, R. E., on the Jubbulpore Gun Carriage Factory Monorail, is also enclosed.

24. For no kind of forest work would I recommend a monorail tramway. If the traffic is light, a 10lb. double line with hand or bullock haulage will be equally portable and of very little additional cost to begin with. The Goalpara line in Assam cost Rs. 6,000 per mile, with 14lb. rails and with hand traction carried about 17,000 ton miles at a rate of under Re. 0-5-0 (includes depreciation and interest). For heavier traffic, say 30,000 ton miles, it would probably pay to have 18lb. rails and 20H. P. engine. The plant would have a capacity of about 84,000 ton miles in 7 months. But for the transport of logs, or other material, which by its nature is difficult to accurately balance when loading, a monorail tramway is the most impracticable system one could choose.

Hints on considering tramway schemes.

25. In considering the question of laying down a tramway plant the following headings may be of assistance—

(1) The amount of traffic and what development is likely to take place.

(2) The present cost of transport in figures per ton mile.

(3) Expert advice, from independent sources, as to the best way of dealing with the traffic.

(4) Personal inspection of existing lines with a view to gaining experience in the laying down and working of tramways, is essential to the framing of a reliable estimate and obtaining the best results from the very beginning.

(5) Whether by altering the working-plan the line can be more suitably served than under the existing sequence of coupes.

(6) Maximum loads, wheel pressures, kind of sleepers and the distance between them.

(7) Whether the amount of traffic justifies steam haulage.
(8) An estimate from a firm or from firms for the plant required.
(9) An estimate of the carriage to the site, the cost of survey and laying.
(10) An estimate of the cost of extracting, by means of the line, the produce available, with details of working expenses, including interest on the capital expenditure (8 and 9) and depreciation on all stock. To begin with the line may not have to be worked for the whole season.
(11) The time that the line will remain on each alignment and the cost of removal and relaying.
(12) Maps showing the areas to be worked and, roughly, the various alignments.

Concluding remarks.

26. There can be no doubt that in the Central Provinces tramways have not received the attention which they merit. A glance at the table below will give food for thought and possibly for action :—

Name of line or route.	Length in miles.	Amount of traffic in ton miles.	Cost per ton mile. By carts. Rs. a. p.	Cost per ton mile. By tram. Rs. a. p.	Remarks.
1. Allapilli monorail ...	4	(*a*) 4,000	1 14 7	1 5 11[1]	[1] The figures include the cost of extraction to the line. (*a*) About 60% of the capability.
2. Shivarajpur monorail ...	20	(*b*)	...	0 7 8	(*b*) Line worked with 60 trucks up to its maximum capability bullock traction.
3. Goalpara 2' guage ...	9½	(*c*) 17,000	0 9 0	0 4 11	(*c*) Figures approximate.
4. Central Indian Mining Company 2' guage.	30	(*d*)	...	0 0 9	(*d*) Line worked with several engines to its maximum capability.
5. Allapilli Warora ...	102	50,000	0 3 0	...	Rates for sawn timber.
6. Allapilli-Chanda ...	72	...	0 3 6	...	
7. Allapilli-Ballapur ...	62	...	0 3 10	...	
8. Compartment 2 Wangapilli...	8	(*e*) 32,000	0 9 3	...	(*e*) Teak logs.

27. Where forests are worked by contractors, or coupes are sold standing a royalty could be charged per truck load carried. It is a mistaken policy of *laisser faire*, to leave works of improvement, requiring a large outlay of capital, to a man who may only be interested in the forest for a year or two. In order to get the best price for produce, Government should provide the capital for the cheapest method of getting it to the market, or, to state the case differently, the aim should be to greatly increase the bulk of forest produce sold, up to the possibility of the forests, and to give the consumer his timber and fuel, but especially his fuel—for on this hinge many problems of agriculture and of grazing, of vital importance to the State—at the lowest price possible. In many cases transport by tramways would prove to be a very great saving on that by country carts. In each division the question should be taken up, and in order to save the re-duplication of labour it would be advisable to place an officer on special duty in these Provinces, to examine existing methods and where necessary to draw up schemes for better and cheaper transport.

Monorail Tramway at the Jubbulpore Gun Carriage Factory, 1901-02.

I.—General History.

1. An estimate was sanctioned for :—

	Rs.
10 miles of rails at	30,000
20 tiptrucks	3,500
1 log wagon bogie at	225
1 platform wagon at	335
Points at	400
Total ...	34,460

2. The line being experimental, less was tried, 6 tiptrucks, a log wagon bogie, a bullock and a hand platform truck on the Caillet system and one platform wagon on the Ewing system were got; and two miles of line laid from the Railway Goods yard to the Factory.

3. This line has been continuously worked; almost entirely by hand labour which could load as well as propel. It has been of great use in checking attempts to raise cartage rates, and supplementing bullock cartage when scarce.

4. At the request of the brick contractor (who was to pay hire and make the subgrade) rails (4 miles) for a double line to the brick fields were afterwards obtained. In the meanwhile, this man obtained the cartage contract permitting him the use of the laid line. After practical experience of the worries given by the labour working it, he decided against using the brickfield line.

5. On lines laid for levelling, the trucking by untrained labour worked out more costly than basket work and was abandoned.

II.—Working cost compared with ordinary transport.

(*a*).—CARTAGE LINE.

6. Three men per truck at 3 annas 6 pies per day, trucking 9 cwt. in 3 trips (12 miles) give a rate, allowing for supervision, of 11 pies per maund.

7. The use of women did not cheapen this. A man was necessary to hold the handle, and 4 to 5 women besides, per truck.

8. This is cheaper than carting; but, at times of pressure, the line could not carry more than 3 tons a day with the trucks and labour available, and required supplementing.

(*b*).—LEVELLING LINE.

9. Three untrained men took one truck load of 13 baskets, in the time they or 3 strong women could carry 12. Allowing for basket carriers between diggers and trucks, and labour to clear line and shift rails, trucking cost more than carrying.

III.—Saving effected by tramway.

10. Before the cartage line was laid, 2,213 maunds were carried for Rs. 189-4-0 or 1·37 annas per maund; but for the Sub-Divisional Officer's personal attention and close supervision the cartage for most of this lot, it would have been much more.

11. Since laying; the cartage contract rate as obtained by open invitation allowing the use of the line to the contractor, is Re. 0-1-0 per maund.

12. At least 11,700 maunds have since been moved by rail or road between the terminals of the line.

13. The saving (at 0·37 anna only per maund) is (Rs. 283) for one year giving 4 per cent return on a capital cost Rs. 7,275 of actual plant used.

14. This total does not include indirect saving or saving on cartage of materials (of large amount) debited direct to estimates, and of which no detail of weights can be traced.

IV.—Causes of small profits.

(*a*).—LESS MATERIALS CARTED THAN ESTIMATED.

15. The whole of the sâl and teak logs used have been delivered by the Forest Department by road direct to site.

16. The site, when opened up, was found to be well supplied with good building limestone.

17. The brick contractor objecting to use the line for his bricks (as the cartage line labour already gave more trouble than he cared for) no line was laid to the brick fields.

(*b*).—DISLIKE OF COOLIES FOR THE CAILLET SYSTEM.

18. This system requires trained labour. The balancing of these trucks requires continuous attention, which worries uneducated labour.

19. Careless moving of heavy loads is dangerous. One bad accident at least occurred with them.

20. If two coolies, by pushing one on each side of a truck, tried to share the lift or loading strains caused by the heeling of the truck, they simply gave mutual discomfort.

21. Women specially dislike these trucks and have struck work rather than use them.

(*c*).—INABILITY TO USE THE LINE FOR PROPER LEVELLING.

22. Proper and economical tram levelling can only be done when the cutting is carried inwards from the intersection of the levelled plane with the natural ground, so that the trucks can be filled by diggers and fillers.

23. Large importation of labour at reasonable rates was not possible owing to other large works in progress in India. The best use had to be made of what was available.

24. The sites of many buildings in the factory require levelling before construction can begin. The labour had to be concentrated on these, so that the levelling excavation was in more or less deep holes requiring, for tram work extra basket carriers between the trucks and fillers.

25. Every man was wanted to dig: the women were all but useless with the trucks: so the tram was not continued.

V.—Points found in favour of Monorail Line.

26. Quick laying by unskilled labour.

27. Working possible with very sharp curves, bent rails and bad laying.

28. A minimum nuisance to ordinary traffic over the same ground.

29. Half the cost of a 2-rail line.

NOTE.—In the following remarks on the systems of trucks used, no notice is taken of the remediable structural defects in the particular trucks tried.

VI.—Caillet Trucks.

(*a*).—ADVANTAGES.

30. Cannot "take charge" down an incline.

(*b*).—DISADVANTAGES.

31. Requires trained hand labour.

32. Wearisome to hand labour.

33. Dangerous with careless handing.

34. The side propulsion, causing:—

(i) Strain on connections between truck and motive power.
(ii) Thrust of wheel flanges against rail, adding to motive power required.
(iii) The combined width of truck and motive power taking up more way than any other system.

35. Each truck requiring an animal or coolie to keep it balanced, they cannot be made into trains, when large motive power (elephants, teams of animals, steam road engine) is available.

36. A truck adapted for one class of motive power, requires complete alteration of the connecting frame work before it can be used for another.

37. In levelling, the low legs (on which a truck is supported when at rest) catch lumpy filling and require clearance.

VII.—Ewing Trucks.

(*a*).—ADVANTAGES.

38. Can be used by untrained labour.

39. Requires moderate width of truck.

40. Can be made into trains.

41. Can be moved by any system of traction available without alterations.

(*b*).—DISADVANTAGES

42. The road wheel :—

(i) Makes traction a little heavier than with other systems.
(ii) Interferes with loading on one side.
(iii) Necessitates a larger radius of curve in the line (for bogie trucks only) than the Caillet.

VIII.—Probable best arrangements of tram system.

43. The result of the trial of the two systems showed that the Ewing was best for carriage. But for the fact that the broad gauge siding was about to be begun, more Ewing trucks would have been got.

44. The Ewing was not adopted for levelling and could not be tried. Possibly the extra traction of the road wheel over the uneven filling would have given unsatisfactory results.

45. Until this matter is settled practically, a 2-rail line appears best in such work, though the monorail line is far more flexible and suitable for unskilled labour to lay and shift.

The Shivarajpur Monorail Tramway.

Twenty miles of monorail tramway with Ewing's patent trucks were laid down for manganese works.

2. Eighteen pound rails were used and it was found that $2\frac{1}{2}''$ section rails were better than $2\frac{1}{4}''$ section, as with the latter the wheel flanges were liable to sheer off the fish plate bolts.

3. Sixty trucks were purchased at a cost of about Rs. 500 a piece. They were to carry six tons; but their construction was faulty and the materials used of an inferior quality, so the bill for repairs and renewals was soon a pretty heavy one.

4. With such heavy loads the sole plates crumpled up and it was found necessary to use sleepers, a size $18' \times 3' \times 9'$ proving most suitable, placed three feet apart centre to centre, and well ballasted with ghitti.

5. The average rate for loaded trucks with bullock haulage is from $1\frac{1}{4}$ to 2 miles per hour and the cost so far has been prohibitive (Re. 0·7·8 per ton mile) owing to almost every detail having to be redesigned by the purchasers, the consequent delays, the high rates for fodder and the heavy mortality among the company's cattle.

6. The friction generated, even after the road surface has been most carefully levelled, more carefully than would be required for a double line, makes draught very heavy.

7. The cost of the line and material, in fair working order as it stands now, is just short of Rs. 9,500 per mile. This includes laying, initial repairs, renewals, and alterations due to bad workmanship and all road work.

8. Many advantages were claimed for the monorail, *viz.*, cheapness, rapidity of laying, skilled labour not required, could be laid along 'kutcha' roads without sleepers and without ballast, and that friction was reduced to a minimum; but it has proved most unsatisfactory and not up to the specification. It is about to be converted into a double rail.

9. The method of fixing the balance wheel is shown in Plate III. It was found necessary to put in the extra support shown by a single line as the wheel bracket tended to bend in towards the truck.

CAILLET SYSTEM OF MONORAIL CAR FOR TIMBER

BULLOCK — TRACTION

SCALE $\frac{3}{4}$ INCH TO 1 FOOT

Figure. I.

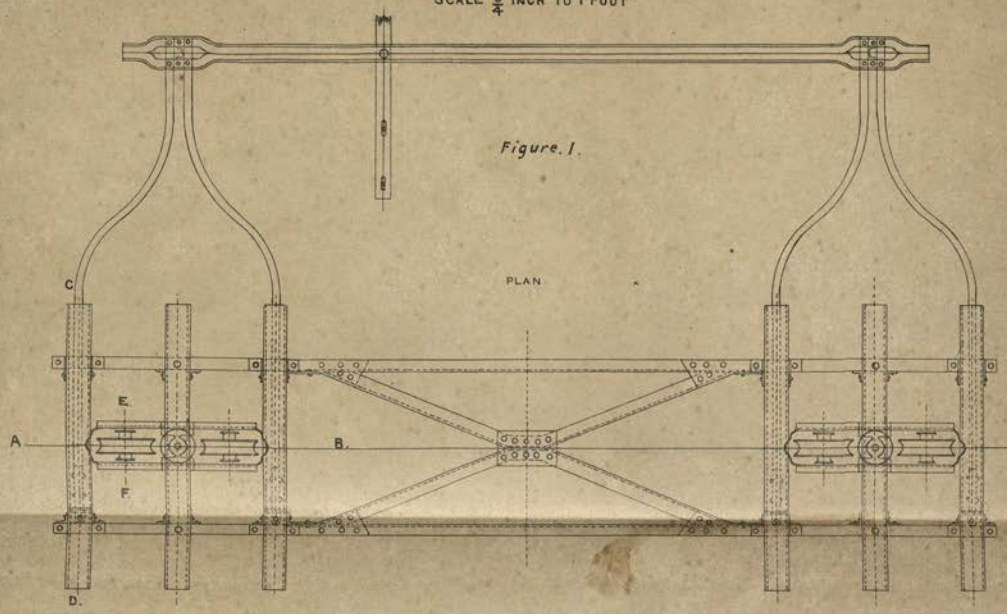

Fig. I. Plan of the truck. The wooden bolsters on which the logs are laid are fixed to the six transverse channel iron pieces by bolts. They have been omitted from the drawing for the sake of clearness. Half of the yoke is shown.

Figure. II.

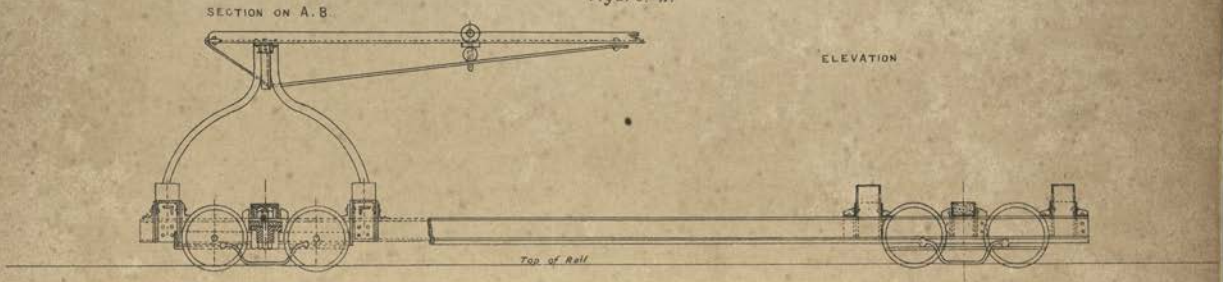

Fig. II. Longitudinal section of the forward bogie taken through A. B. and the longitudinal elevation of the rest of the truck. Only the forward half of the yoke-attachment is shown.

Figure. III.

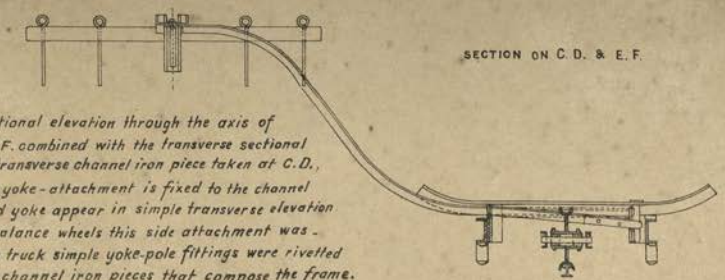

Fig. III. Transverse sectional elevation through the axis of the forward wheel taken at E. F. combined with the transverse sectional elevation through the forward transverse channel iron piece taken at C. D., showing how the flat S. shaped yoke-attachment is fixed to the channel iron. The yoke-attachment and yoke appear in simple transverse elevation

On the addition of the balance wheels this side attachment was removed and at either end of the truck simple yoke-pole fittings were rivetted to the ends of the longitudinal channel iron pieces that compose the frame.

PLATE 2.

BALANCE WHEEL OF THE ALLAPALLI MONORAIL TRUCK.

Scale 1½ inch to 1 foot.

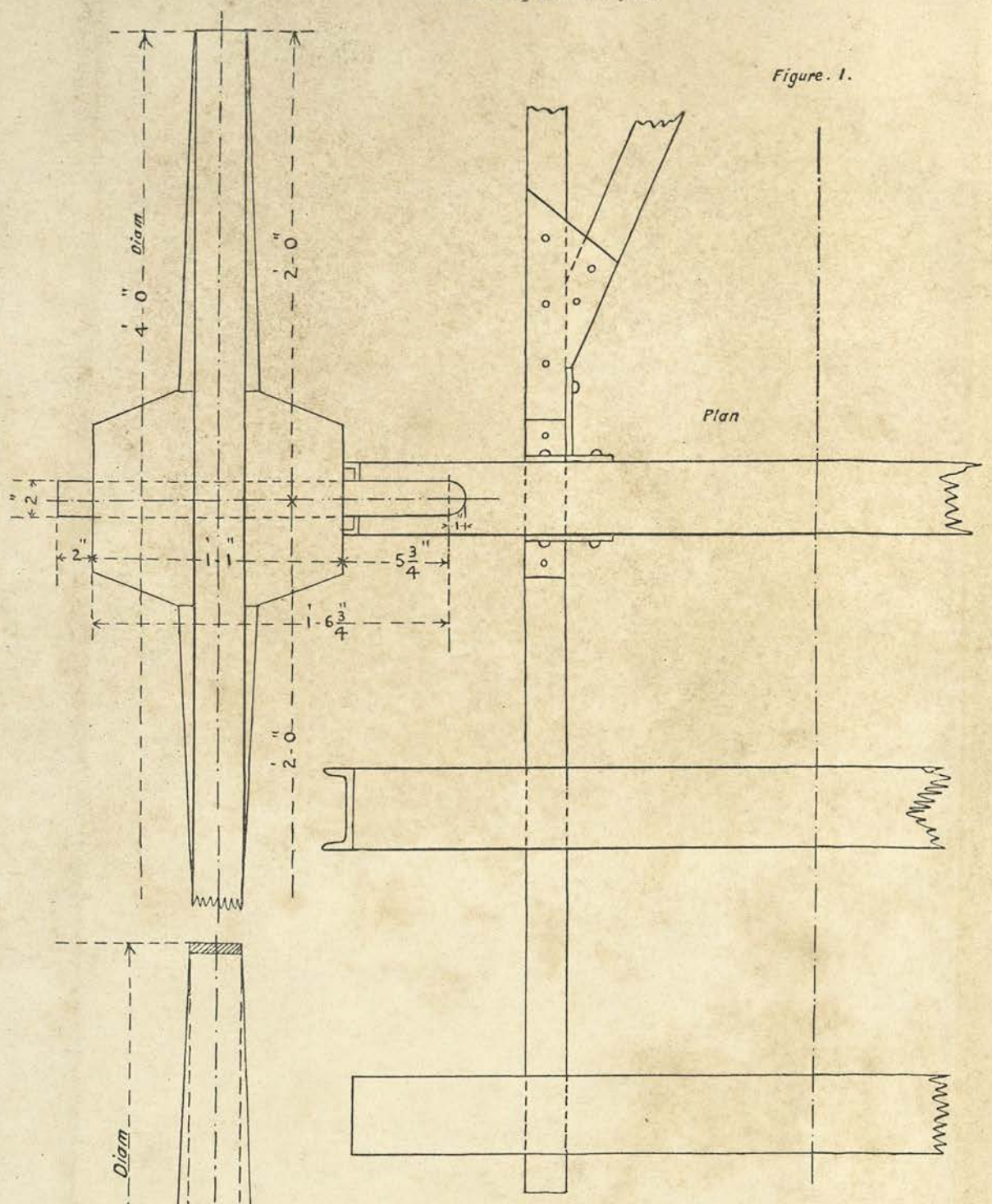

Figure. 1.

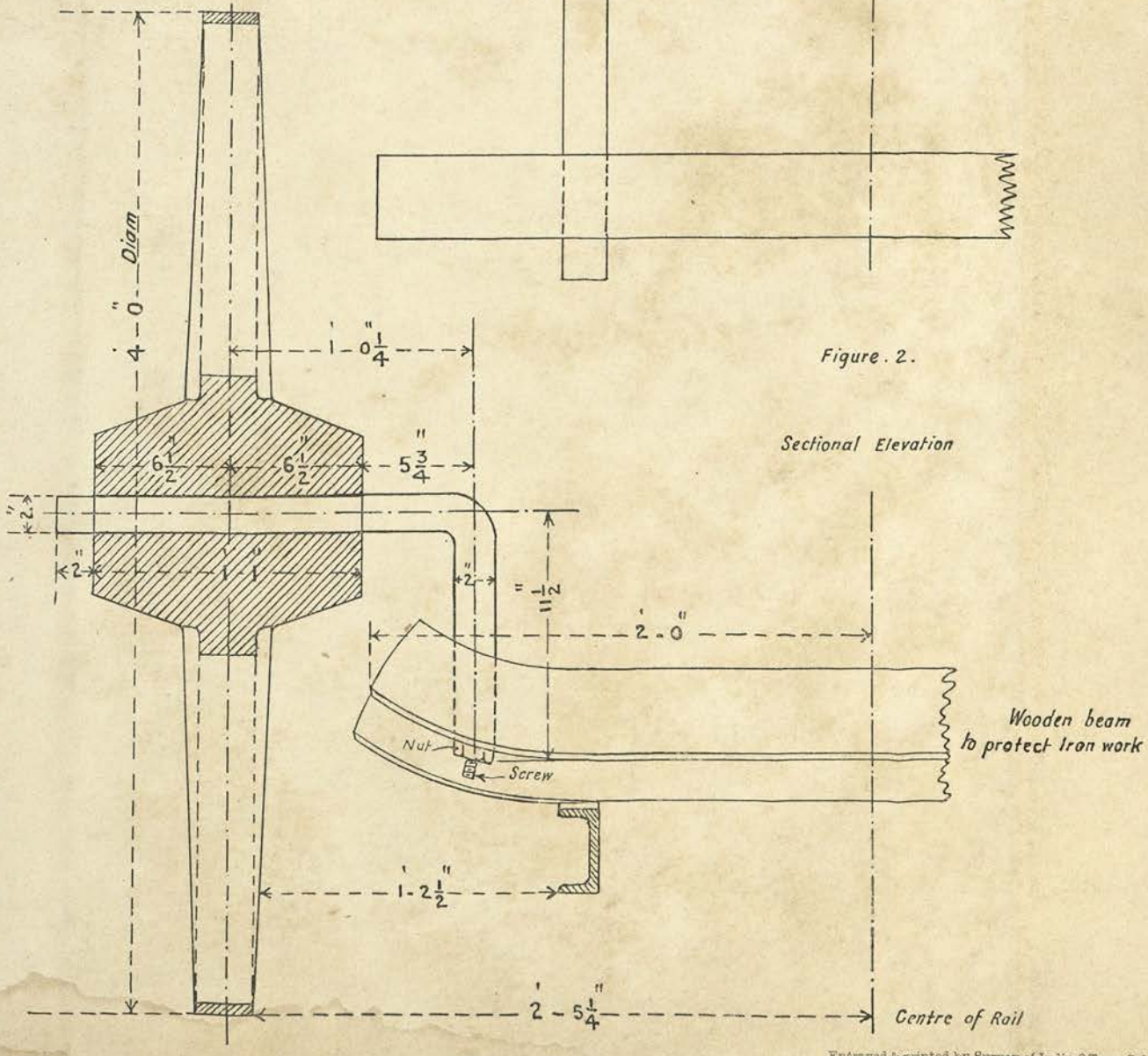

Figure. 2.

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PLATE 3.

BALLAST CAR OF EWINGS MONORAIL SYSTEM.

Scale ½ inch to 1 foot.

Figure. 1

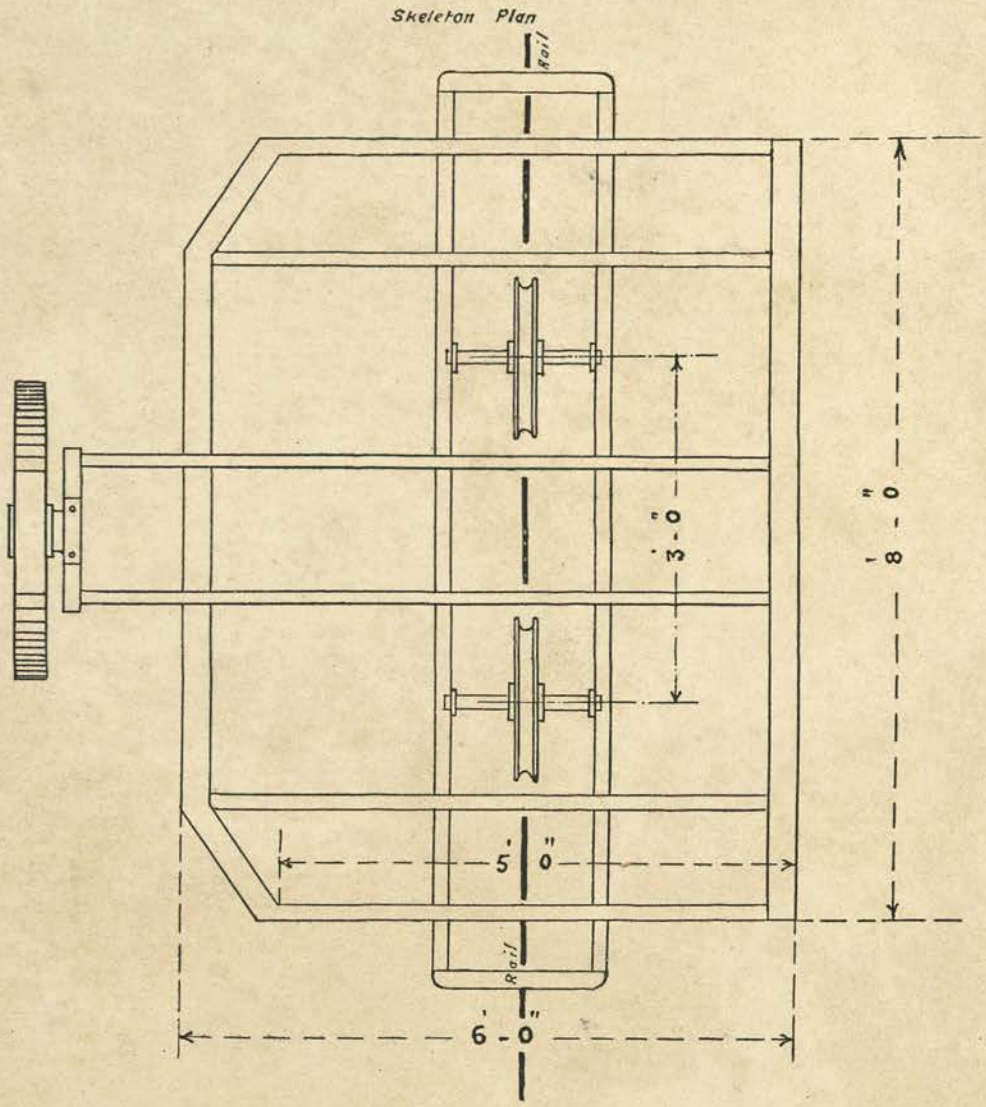


Figure. 2.

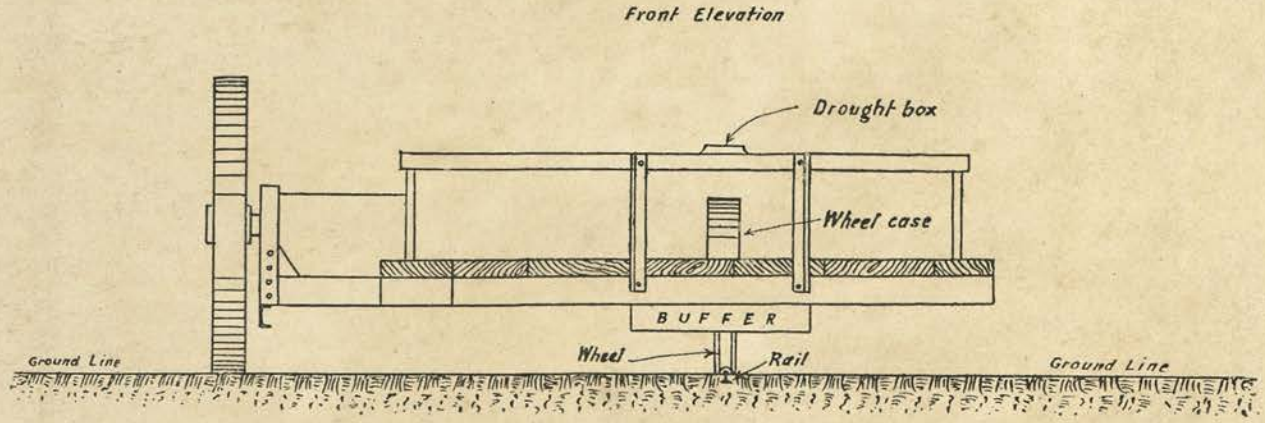
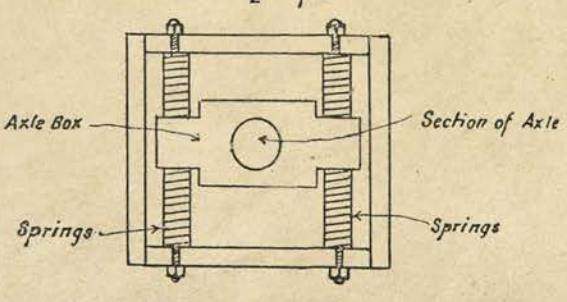


Figure. 3.

Side view of the spring axle box on the truck

Scale 1½" = 1 foot



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DISCUSSION ON MR. DONALD'S PAPER.

The Conference first considered the question of the suitability of monorail tramways to the transport of forest produce and then, as there was time, discussed the more general question of the introduction of other mechanical means of transport.

Mr. Donald's experience of the practical working of Caillet's monorail at Allapilli has led him to condemn it as unsuitable for the transport of logs, chiefly on account of the difficulty of loading the trucks and of maintaining the balance of the load in transit. The experience with Ewing's monorail tramway, constructed to carry manganese, confirms Mr. Donald's experience; while that of the monorail tramway in the Jubbulpore Gun Carriage Factory has not been the success than was hoped, when it was put down. It is therefore quite established, so far as the transport of forest produce is concerned, that an ordinary two rail tramway is much better than any monorail system that has at present been tried, on account of the simplicity of its working, the ease with which the trucks can be loaded and unloaded, and the fewer break downs which occur. The use of one rail necessitates the balancing of the load and it is this makes this system unsuitable for forest work. The trucks lose their balance very easily, frequently upset and are damaged, whereas in the case of an ordinary two-rail tramway the trucks rest on two rails and very rarely leave them.

In the general discussion which followed it was agreed, that in the past the suitability of many of the mechanical means of transport for the purpose for which they were required had not been sufficiently considered before the particular means of transport had been finally selected; that the determination of the particular means of transport for any given purpose, could only be determined by a Forest Officer who had specially studied the subject, and that it would be in the interests of Government, to appoint an expert in mechanical means of transport to advise Divisional Forest Officers, and to decide whether it was practical or not, to adopt any labour saving mechanical means of transport; and that if such an officer were appointed much unproductive expenditure would be saved.

In India, where labour is so cheap, it is only rarely, that the introduction of mechanical means of transport is economical. Good cart roads are in the vast majority of cases more economical than mechanical means of transport, and that consequently the cheapest way of opening up Government forests will usually be by the construction of well graded cart roads. The expert on transport of timber would be very usefully employed on reporting on road projects prepared by Divisional Forest Officers, and in advising them in the preparation of schemes for the construction of systems of roads for opening up the forests under their charge.

It was generally felt, that schemes for roads had also not received the attention in the past that they should have done, and that there is work immediately for a whole time officer to supervise the construction of cart roads and the economical introduction of mechanical means of transport, with a view to cheapening the cost of extraction of produce from Government Forests. **At the close of the discussion *Resolution No.* 21 was framed and passed.**

RESOLUTIONS PASSED ON MR. DONALD'S PAPER.

Resolution No. 21.—That the Monorail Tramway System can only be used for the transport of easily balanced loads, but is not, as a rule, suitable for the transport of heavy logs. That before adopting any mechanical means of transport, it is advisable that a careful enquiry should be made into the advantages, and disadvantages of roads, ordinary tramways, monorails, road trains, or ropeways, etc., which may be considered suitable, by a Forest Officer who has made the various methods of transport of forest produce a special study.

Resolution No. 22.—That this conference agrees that the question of transport is one great importance that has not received sufficient attention in these Provinces in the past.

Resolution No. 23.—That the appointment in these Provinces of a specially trained forest officer to enquire into the conditions and possibilities of divisions, where the local officers consider that the existing transport arrangements are insufficient or might be improved is urgently required, and that this conference consider that Mr. Percival, Deputy Conservator of Forests, who has recently had exceptional facilities for studying up to date methods of extraction in Europe, and who has gathered statistics on the subject from all parts of India, in connection with the preparation of a Manual of Forest Engineering, is specially suited for the post.

SECTION V

(1)—PAPER ON THE INFLUENCE OF, OR PROTECTION FROM, CATTLE-GRAZING IN THE FORESTS OF THE BHANDARA DIVISION, SOUTHERN CIRCLE, CENTRAL PROVINCES.

(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTIONS PASSED.

THE INFLUENCE OF AND PROTECTION FROM CATTLE GRAZING.

Since the earliest times, when forests were managed with the view to game preservation, to the present money-making era, when forests are managed silviculturally, with the view to the best financial results possible, the grazing question has always been a matter for discussion and legislation. In England, as a survival of ancient laws, sheep are not "beasts of common" in the eyes of the law, and can therefore have no right over common or waste land which other animals may enjoy, disabilities which the animal owes to the fact that deer will not feed over land pastured by it.

In the Central Provinces, where forest administration and protection is comparatively recent, and is carried out with a direct financial object, and the supply of timber and other forests produce, grazing is only allowed as a privilege, and as a general rule the grazing of goats in reserved forests is prohibited.

It is only within the last 15 years, since fellings have been restricted to defined areas, that the privilege of grazing cattle within our forests has been limited to localities where they can do least harm. There are, however, areas in the Bhandara Division, where protection from grazing has been carried out for a sufficient number of years in succession, to afford data for a discussion on the subject of the effects of excessive grazing on, or successful protection from grazing upon, the general condition of the forest and soil.

The Bhandara forests are of the ordinary Central Provinces type, the following species being prevalent:—*Terminalia tomentosa* (Saj), *Lebidieropsis orbicularis* (garari), *Diospyros melanoxylon* (tendu), *Anogeissus latifolia* (dhaura), *Bassia latifolia* (mahua), *Buchanania latifolia* (achar), *Soymida febrifuga* (rohan), *Butea frondosa* (palas), *Pterocarpus marsupium* (bijasal), *Lagerstraemia parviflora* (lendia). Bamboos and a few teak are found on rising ground and along the banks of nallas.

The forests which cattle frequent are on flat ground, with either a sandy loam or a black-cotton soil. The underlying rock is either gneiss or laterite. The rainfall averages about 50 inches. Otherwise the climate is the same as elsewhere in the Central Provinces, but frosts are uncommon and have little influence on the forest growth.

The observations on which this paper is based are made from—

(*a*) forests in which no fellings of green wood have been allowed for 16 years, but in which grazing has been permitted;

(*b*) forests in which improvement fellings in high forest, of the nature of cleanings have been made, but in which no grazing has been allowed for the last 11 years; and

(*c*) forests worked under coppice with standards, open ordinarily to grazing, but closed for 10 years after fellings have been carried out.

The typical over-grazed forest in which no restrictions to the pasture of horned cattle are prescribed, shows a great tendency to become patchy, and the most promising regeneration is usually found in thick groups of poles and saplings, protected either by thorny growth which the cattle avoid; or by inferior growth on the outside of the groups, which helps to prevent the cattle from reaching the young trees within, and so damaging, the leading shoots, or trampling down seedlings. Often regeneration is found in the group formation sheltered by some old mohwa or other large tree. In this case the localized regeneration has little to do with protection from cattle; it is more probably caused by the protection from atmospheric influences afforded by the shade of the tree, or possibly by the annual disturbance of the soil by the sweeping up or collection of the mohwa flowers.

Another phenomenon due to excessive grazing is the curious growth of young *Saj* trees. I have in many places seen considerable areas of forest the soil of which is completely covered by young *Saj* (Terminalia tomentosa) trees up to 18 inches in height, very much branched and stunted in growth. On being dug up these plants will be found to have a thick and distorted stem at or just beneath, the surface of the ground. It is possible to ascribe this condition of growth solely to forest fires.

I think that excessive grazing has more to do with it however, because the phenomenon is as common inside forests, which have been successfully protected from fire for a number of years, as it is in forests where protection has not been attempted; and one would expect these young trees to recover after protection from fire for a number of years. Our best forests in Bhandara are always protected from fire; but, with the exception of the small area taken up by the high forest working circle in Gaikhuri Range, none of our forests are protected against cattle-grazing for a greater period of 10 years.

In the High Forest Circle, where protection from cattle has been carried out for the last 11 years, this condition of the *Saj* regeneration, although present is not common; it must, however, be borne in mind that previous to protection, the ground was probably grazed as heavily as elsewhere.

In places, such as steep hills where, owing to their inaccessibility, cattle never graze, stunted growth of young *Saj* is absent and incidentally the regeneration of all species is in a considerably more satisfactory condition than in the level forests.

The cause of this abnormal growth of *Saj* can be ascribed not so much to the browsing of animals as to their continuous trampling. This would account for the thick stem at the surface of the ground. If stems are continually, year after year, beaten down and mutilated, they could not be expected to send out a strong leading shoot, more particularly as the soil over the roots becomes hard through continuous trampling.

On the sides of steep hills where cattle seldom if ever graze, there are usually a sufficient number of stones to prevent the trampling down of the seedlings as well as of the soil, hence the comparatively good regeneration on the hill sides.

I have observed a similar condition of growth of *Teak* in the heavily grazed Salai block of the Partabgarh Range, but to a less extent. The difference being that the scattered Teak seedlings are mostly affected, but subsequently recover, owing to their power of sending out a strong vigorous leading shoot from an old root, the strong side shoots remain for a number of years and then under favourable conditions subsequently die off. Where the regeneration is thick however, trampling has not taken place, due no doubt to the immunity of Teak foliage from browsing.

A similar stunted growth of *Tendu* (Diospyros melanoxylon) is often seen in very heavily grazed Malguzari forests near villages. The stunted seedlings being thick and close together as in the case of *Saj* and due no doubt to the same causes.

Continual overgrazing has a marked influence, not only upon the distribution and growth of trees already discussed, but also upon the prevalent species found in the forest. It is natural that after a number of years of heavy grazing, those species which cattle prefer to eat would diminish in numbers, and those favoured species, the leaves and shoots of which are not liked by cattle, should after a time predominate.

Consequently the *Gardeniæ*, *Zizyphus œnoplia*, *Butea frondosa* and *Teak* are particularly favoured, in a negative manner, by the grazing of cattle, and one or more of these species are usually found in marked evidence, where heavy cattle-grazing has been allowed for a number of years.

With the closure of the area to grazing and the improvement of the forest growth due to fire protection, the *Gardeniæ* disappear, but in any case their presence in the forest is not a serious drawback, as they form a suitable soil covering and do not grow high enough to hamper the growth of other species once established.

Zizyphus œnoplia, so far as weeds are concerned, is the greatest pest in Bhandara Division. Dense masses of this weed are found wherever extensive grazing has taken place, and owing to the thorny nature of the climber, the forest is rendered in many cases impenetrable to man and beast. Groups of this weed sometimes form a nucleus for a group of regeneration of useful species, by the protection it affords, through its thorns, against cattle; but more often it prevents the healthy growth of more valuable trees by an extension into their crowns. It is a pest to any forest in which it is found and is a great hindrance to wood-cutters, who do not like to deal with trees surrounded by dense masses of climbers armed with hook-shaped thorns.

The permanent suppression of this pest will be a task of great difficulty. I have observed in Matora Working Circle that three years after complete coppice fellings have been made the *Zizyphus* thorns have got above the young coppice growth. It will be interesting to observe whether the complete protection from cattle-grazing will give the other and valuable species sufficient opportunity to suppress these thorns. Sufficient data are not as yet available. Certainly *Zizyphus œnoplia* is less common in areas in which protection from cattle has been carried out for a number of years. It is unfortunate that we have no information regarding the previous state of any particular area which is now free from *Zizyphus* before protection.

With the introduction of forest journals, with entries for each compartment, we should be able to obtain information of this nature in the future.

In the High Forest Circle in which protection against cattle has been carried out for years, and where there is a good healthy growth, *Zizyphus œnoplia* is not present to any appreciable extent. The pest is also not found on hilly ground where cattle go very little to graze.

In the coppice working circles, however, where closure against grazing is only extended over ten years after fellings, it is a question, considering the manner in which the *Zizyphus* climber gets above the coppice shoots after three or four years, whether it would be possible to get rid of all traces of the pest by silvicultural treatment, before the area would again be open to grazing. Probably if the coppice were comparatively free from the pest for ten years, the dense growth arising from the coppice shoots would be capable of keeping the thorns down.

Butea frondosa is another species not eaten by cattle and therefore favoured in the struggle for existence in heavily grazed areas. The species is valuable for its lac-producing properties and its roots. It occurs pure, on black-cotton soil, in heavily grazed areas near the villages. There are few trees that thrive on the black-cotton soil, and lac cultivation with unlimited grazing would appear to be the correct treatment for such places. It is not usual to find *Butea frondosa* pure in grazed areas, except where black-cotton soil occurs, otherwise the species merely shows a greater frequency of occurrence in grazed areas than elsewhere.

The most important species favoured by grazing is *Teak*, and if it were not for the aversion of cattle to browse on this species, there can be no doubt that *Teak* in the Central Provinces would be a comparatively rare species. The frequent occurrence of *Teak* trees in grazed Malguzari areas, adjoining Protected Government forests with a similar soil, &c., where they are not so common or where the regeneration is not so good can be ascribed to this cause. Cattle-grazing in Bhandara Division is actually favourable to *Teak* regeneration, because it protects the young seedlings from suppression by other species. It is true, as already remarked, that the seedlings are at first trampled down, but owing to their capacity of sending out a strong leading shoot, the young *Teak* survive the rough treatment. The best regeneration of *Teak* in Bhandara Division is found in the two most heavily grazed areas, namely, the Margali Circle of Bawanthari Range and the Salai grazing block of the Partabgarh Range.

The height-growth of *Teak* in these conditions is not satisfactory. As there are not, however, sufficient examples from which any definite conclusion can be drawn, statements of this nature must be made with caution, but certainly there are no *Teak* of a good height and girth-growth in the heavily grazed areas of the Bhandara Division.

An interesting condition in connection with the heavily grazed Margali Circle in Bawanthari Range is that the southern portion, where there are few *Teak*, is so heavily grazed that there is practically nothing to burn in the hot weather; the northern portion thus benefits by cattle-grazing, not only through the favouring of its most valuable species, but also by the natural fire protection afforded by the heavy grazing to the south. Similar conditions are, I believe, found in the Arvi and Khondali ranges of the Nagpur-Wardha Division.

The following description of the growth in a typically overgrazed forest, compared with that of a forest successfully protected for a number of years in Bhandara Division, extracted from my Forest Journal, will be of interest :—

MARGALI BLOCK, BAWANTHARI RANGE (OPEN TO GRAZING).

" The Geological formation is mica schist and the soil is a sandy loam of suitable depth for tree growth. The soil covering is scanty forest growth and *Gardeniæ*, or a thin layer of fine grass on ground not shaded by trees. The growing stock includes the following species :—*Saj*, *Tendu*, *Garari*, *Lendia*, *Khair*,* *Achar*, *Mahua*, *Rohan*, a few *Bijasal* and also *Teak*. *Palas* is found throughout, but where black-cotton soil occurs it is found pure. Height-growth is poor. The actual stocking is about 0·4 compared with a fully stocked wood with a complete leaf canopy. The trees are usually grouped together and are not scattered evenly over the ground. *Zizyphus œnoplia* is very common and renders the forest impenetrable in many places. Regeneration is poor with the exception of *Teak* which is satisfactory. Regeneration *Bijasal* is practically absent."

HIGH FOREST CIRCLE IN GAIKHURI RANGE (CLOSED TO GRAZING).

" This is a typically protected area under similar conditions with the same soil and geological formation. Forest growth or coarse high grass forms the soil covering. *Gardeniæ* not frequent. *Palas* uncommon and *Zizyphus œnoplia* rare, otherwise the species found are the same. The stocking is complete or nearly so and the ground is covered by young growth. The distribution of trees is uniform and not arranged in groups. Regeneration good. *Bija* and *Teak* regeneration good. Height-growth good."

Of course, it must naturally be taken into account that the grazing area would never have been given up to grazing, if it held good forest, and the high forest was probably so constituted because of its good growth. Both areas have been protected from fire for a number of years. In the Margali block there are signs of erosion of the soil taking place which I have not observed eleswhere. As this paper is based on observations from forests protected or otherwise for the last 16 years only, any conclusions that may be deduced from it must, of course, be accepted with caution, more particularly on the subject of soil erosion. The observations on the actual growing stock are, I hope, of sufficient interest to draw opinions of officers stationed in localities where the conditions brought about by the grazing to cattle are different.

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* Acacia catechu.

PLATE 1.

Figure 1.

Root shoots of Diospyros melanoxylon (Tendu), in a village area in the Raipur District, C. P.
(Photograph by A. E. Lowrie.)

Figure 2.

Engraved & printed by Survey of India Offices, Calcutta, 1909.

Root shoots of Diospyros melanoxylon (Tendu), which do not develop a tap root and remain stunted.
(Photograph by A. E. Lowrie.)

PLATE 2.

Engraved and printed by Survey of India Offices, Calcutta, 1909.

A series of dwarfed seedings of Terminalia tomentosa (Saja), 1, 2, 3, 4, 5, 10, and 15 years old in the Raipur District, C. P. (Photograph by A. E. Lowrie).

DISCUSSION ON THE HON. J. BEST'S PAPER.

Mr. Best opened the discussion by emphasizing the great importance which must needs be attached to the management of grazing in the forests of the Central Provinces, and to the increasing demands on the forest in consequence of the steady increase of cultivation and diminution of the areas of waste land. He said that the provision of sufficient area to provide grazing for the agricultural cattle in the Province was one of the most important problems which the Working Plans Officer of the future would have to solve. Before 1893, the year in which working plans were sanctioned for the Bhandara Division, no restriction was placed upon cattle-grazing. Under the provisions of the working plan, grazing management was introduced by the restriction of grazing in some forests, and its prohibition, either entirely or for a term of years after the area was cut over, in others. Large areas, however, still remained open to unrestricted grazing. Consequently a comparison of the condition of the areas closed and open to grazing might allow some idea being found of the actual harm done by, or benefit derived from, cattle-grazing. Mr. Best continued by saying that his object in writing his paper was to obtain the experience of Forest Officers in other parts of India on this important question. He drew special attention to the presence of the dense masses of *Zizyphus œnoplia* in the areas open to grazing and asked if similar results had been observed elsewhere; invited discussion on (1) the effect of grazing on the production of Teak and its subsequent growth; (2) the length of the period for which areas should be closed after having been cut over; (3) the measures to be taken to meet the increasing demand for fodder grass, consistent with the maintenance of the supplies of timber and fuel.

Before the general discussion on the points raised by Mr. Best was begun, the probable origin of the dwarfed *Tendu* and *Saj* shoots was considered. Mr. Lowrie handed round photographs showing the underground root system and shoots of *Tendu* (Plate I) and the development of *Saj* seedlings for the first 15 years of their life (Plate II). In the case of *Saj* Mr. Lowrie's investigations show that the abnormal growth is not necessarily due to grazing, but may be attributed to unsuitable soil. The seedling is either grazed off, or dies back naturally, year after year, and sends up a new shoot each rainy season; the root meanwhile thickens and becomes carrot shaped. This process goes on until the tap root reaches a soil which is favourable to it, when a strong healthy shoot is sent up, which persists and grows on into a tree. The same dwarfed growth of *Saj* is commonly found in areas closed to grazing, usually in frost holes. Here the frost kills off the shoots produced annually, year after year, and it is only when the shoots are protected from frost that they ever develop into trees This well-known phenomenon corroborates Mr. Lowrie's observations.

As regards *Tendu* Mr. Lowrie's investigations show that the so-called seedlings are really root suckers. He has traced these roots for many yards, and has been able, in many instances, to show that large patches of these dwarfed shoots have originated from a single tree, the stump of which can often be traced. The shoots appear to be the direct result of cattle-grazing; the root suckers are close to the surface, during the rainy season pieces of the bark are knocked by the feet of the grazing animals and the shoots spring up wherever the bark is injured in this way. These shoots develop no tap roots and cannot grow into trees. Unless the root suckers are injured no fresh shoots are developed. Mr. Witt and Mr. Fisher both confirm Mr. Lowrie's observations that the root suckers can be nearly always traced back to their parent trees. Mr. Malcolm stated that dwarfed shoots of Tendu and Tiwas (*Ougeinia dalbergioides*) so commonly found in temporary cultivation are also root suckers and not seedlings.

Turning to the general grazing question it was unanimously admitted that although the great and increasing amount of the damage done by excessive grazing was universally admitted, and viewed with great anxiety by the Forest Officers responsible for the conservative management of the Government's valuable forest

estate, no definite information had at present been collated showing—

(1) the maximum number of

(2) the kind of

cattle which can be allowed to graze in forests, consistently with their proper management, and Mr. Witt's proposals to take steps to collect information on this subject was adopted by the Conference as *Resolutions* 24 *and* 25. As the number of cattle per 100 acres of area open to grazing must vary considerably with the type of forest, the factors of the locality, and the object with which the forest is worked, *i. e.*, solely for the production of timber or fuel; for the production of timber, fuel and fodder grass; or as permanent grazing grounds; it is necessary that all Divisional Officers should collect information on lines which will have to be carefully laid down. When this information is available it was felt that the Local Administration would be in position to determine the number of cattle that can be admitted into any block of forest—in the interests of the country at large—and of surrounding agriculturists. The intensity of grazing must necessarily vary with the object for which the forests are worked. When, in the interests of the country, a forest block has to be worked for the production of the greatest possible quantity of timber and fuel, it follows that the number of cattle which can be admitted, must be very much smaller than if it is required to obtain some fodder grass as well, or the block is to be maintained permanently as a grazing ground. Even in this last case it is very necessary to limit the number of cattle admitted to a certain extent, or as has already happened in some parts of Berar, not only will the more valuable, and, as a rule, more delicate species of grass be killed out, but the amount of grass—of any kind—will become less and less, until the soil becomes too poor to grow grass even, and ultimately becomes absolutely improductive. The question of the amount of grass eaten and destroyed by trampling by buffaloes and cows or bullocks also requires careful study. It is admitted that buffaloes in virtue of their greater weight, and less fastidious tastes, do a great deal more damage to forests, both in the rainy season and during the hot weather, when there is very little, if any, grass, than cows: but definite information on this subject is urgently required.

The Conference then discussed the question of the length of the period for which areas should be closed after they are worked over. It was generally admitted that the present procedure of closing all areas that are cut over for ten years requires reconsideration. Some period of closure is undoubtedly necessary, but it is not possible to lay down any hard-and-fast rule on such a subject where local conditions vary so much. It was the opinion of the meeting that the period for which the areas should be closed should be left to the Conservators, and that they should be given an absolutely free hand in the matter (*Resolution No.* 26). Instances were brought forward by several Forest Officers where the admission of light grazing of cows and bullocks, but not buffaloes, for a prescribed period, the same year that the existing crop was removed, was actually beneficial in keeping down harmful weed growth. It was generally felt, however, that these were exceptional cases and that the benefit derived from the admission of light grazing for a short period (generally during the rains) depended upon the possibility of turning the animals out of the forest as soon as the growth of grass and weeds had been checked; in other words on the absolute control of the grazing by the Divisional Forest Officer, and that unless this control was absolute, the harm done by grazing would far outweigh any possible good that might result from it.

The next question considered was that of the economical utilization of fodder grass and the encouragement of stall feeding. It is generally admitted that grazing is a very wasteful way of using grass, but no experiments appear to have been made to prove that such is the case; it was resolved (*Resolution No.* 27) consequently that steps should be taken to obtain figures in support of this statement and to show the increased number of cattle which can be fed if the grass is cut and given to the cattle instead of allowing the cattle to graze on the area. The question of the season of the year at which fodder grass should be cut was also considered. The best time for cutting fodder grass is just after the rains before the grass seeds and dries up. This is well-known to all agriculturists, but owing to the difficulty of getting labour, comparatively little grass is removed from the forest at that time of the year, and dry grass, which is much less nourishing, is subsequently cut. The introduction of a sliding scale of royalty for fodder grass, which has been tried in some parts of India with considerable

success, was suggested. The royalty charged in the months in which fodder grass should be removed being reduced, and that in the other months raised, so as to encourage the removal of as much grass as possible in those months in which it is most nutritious. No action can be taken by the Conference, but it was generally admitted that a sliding scale of royalties should be tentatively adopted, with a view to bringing about this very desirable change. The effect of burning on the quality and quantity of fodder grass was also brought up. Mr. Donald stated that an experiment to determine this had been instituted in the Madras Presidency, but that it had not been carried on long enough to allow of any information on the subject being published. The general effect of fire is to exterminate the finer annual grasses, which are the most nutritious, and to encourage the growth of the coarser perennial varieties which are only good for fodder when quite young; consequently the annual burning of fodder grass areas must have a harmful effect on the nutritive properties of the grasses produced.

At the final meeting of the Conference, the Hon'ble the Chief Commissioner, Mr. Craddock, suggested that in localities where the demand for fodder grass exceeded the existing natural supplies in the forest, an attempt should be made to induce forest villagers to grow fodder crops instead of cotton or food-grains, and a resolution was passed (*Resolution No.* 28) that experiments should be made in conjunction with the Agricultural Department to ascertain what fodder crops are likely to be most suitable for this purpose. Unfortunately, as a rule, forest villagers are generally established in out-of-the-way, backward parts of the country where the natural fodder supplies are more than sufficient to meet the demand on them in ordinary years.

RESOLUTIONS PASSED ON MR. BEST'S PAPER.

Resolution No. 24.—That this Conference views with great concern the increasing damage that is being done by excessive grazing in certain forests which are set aside, or required for, the maintenance of a permanent supply of timber and fuel for the local population; and that the Forest Department should at once take up the preparation of statements to show the maximum number and kind of cattle which should be allowed to graze in each forest, with a view to the limitation of the numbers admitted to that which is consistent with the proper treatment of the forest.

Resolution No. 25.—That investigations should be made as to the number, and kind of animal which can be admitted to the several types of forest in the Central Provinces without injury to the growing stock or grass on the area. That as no reliable figures are at present available showing the amount of grazing that can be allowed in forests without causing a marked deterioration of the forest growth or grass on the area, investigations should be made to determine the number and kind of animal that can be admitted, and the period of the year for which grazing may be permitted in forests reserved for the production of timber and fuel, in order that the largest number possible of agricultural cattle in the vicinity of a reserve may be admitted. Special attention should be paid to the comparative requirements of buffaloes or cows or bullocks.

Resolution No. 26.—That this meeting, while recognizing that in special cases beneficial results may sometimes be obtained by opening areas worked over to light grazing, under strict control, for part of the year, considers that investigations should be made as to the advisability of admitting a limited number of cows and bullocks, under strict control, into coupes worked for timber and fuel after they have been cut over, in order to keep down harmful weed growth.

Resolution No. 27.—That an investigation be undertaken into the benefits derived from the cutting of fodder grass, with a view to encourage stall feeding of agricultural cattle and to determine the most economical methods of utilizing the existing fodder supplies.

Resolution No. 28.—That investigations should be undertaken, in consultation with the Agricultural Department, with a view to determining, in localities where the demand for fodder grass exceeds the existing supplies in the forest, what fodder crops could be grown at a profit instead of cotton or food-crops by forest villagers.

SECTION VI

(1)—PAPER ON THE GERMINATION AND DEVELOPMENT OF *HARDWICKIA BINATA* (ANJAN).

(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTION PASSED.

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PAPER

ON

THE GERMINATION AND DEVELOPMENT OF *HARDWICKIA BINATA* (ANJAN)

BY

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THE SYLVICULTURE OF THE ANJAN (HARDWICKIA BINATA).

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Indian Trees, D. Brandis, page 250.
A Manual of Indian Timbers, J. S. Gamble, page 276.
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Do. Volume XXX, page 123.
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II.—DESCRIPTION OF THE SPECIES.

A large deciduous tree. Bark ½ inch thick, dark grey, rough with irregular vertical cracks, exfoliates in narrow flakes. Sapwood, small, whitish. Heartwood, dark reddish brown, very hard and heavy, close and fine grained, very durable, weight 82 lbs. per cubic foot. Leaves bifoliolate; leaflets sessile, entire obtuse, obliquely ovate or semi-cordate with 4—5 arcuate nerves. Stipules small, cordate, caducous. Flowers greenish yellow, on long slender racemes, arranged in axillary or terminal panicles; pedicels shorter than flowers; bracts minute, caducous. Ovary oblong, style ascending with a large peltate stigma. Pod lanceolate 2—3 inches long with parallel longitudinal veins, a solitary seed near the top.

III.—UTILITY.

The dark reddish brown heartwood is used for house posts and bridges and for ornamental work, being very durable. It is liable to split, but does not warp. It has been used for sleepers on the Rajputana-Malwa Railway. Sleepers buried at the Forest College, Dehra Dun, when dug up in 1893, after 7 years in the ground, were found still perfectly sound in every respect.

The bark yields a valuable fibre, and the leaves are much relished by cattle, for fodder. In Berar and South India, the trees were formerly much pollarded for cattle fodder.

IV.—DISTRIBUTION.

1.—General.

The dry forests of South and Central India, but not everywhere. Generally gregarious in patches of greater or less extent. In South India its chief localities are—in Godaveri in the forests round Bandrachalam, in Kistna in the Bollapilli Reserve; also in Bellary, Cuddapah, Kurnool. Further south, on both banks of the Cauvery in Salem, and on the Balarangams in Coimbatore.

In Central India the tree is found in Chanda, parts of Berar, Khandesh, Nimar, Hoshangabad, and Indore State as far North as Mhow. The peculiarly local nature of the distribution of this species is but one of its many and interesting peculiarities and much local knowledge will have to be gathered together and put on record, before a satisfactory explanation is forthcoming. Soil and climate, usually the most powerful factors in determining the limits of a species do not supply in this case, the solution to the question, though the former affects the quality of the growth to a very great extent.

No better evidence could be adduced than a study of the distribution of the Anjan in the Nimar District of the Central Provinces, with which the writer has had four years' experience. The writer proposes to deal with this point at some length, since a just appreciation of this peculiarity is necessary in considering the other sylvicultural peculiarities of the species, and any theories for the successful treatment of it whether these theories be based on ascertained facts or on mere deductions from general observations.

In order to draw attention to this peculiarity of the Anjan, it is necessary in the first place to describe the physical features and the geology of the Nimar District.

2.—Physical Features of the Nimar District.

Almost through the centre of the district from West to East runs a branch of the Satpuras forming the water-shed between the Nerbudda river on the North and the Taptee on the South. Practically the whole of this ridge is Government reserved forest. Between this range of hills and the Nerbudda river lies the town of Khandwa in a broad and fertile valley. The drainage from the central ridge to the North is diverted from its direct course by another low and irregular ridge, constituting the forests of the Khandwa Range. This particular block will be alluded to again later on. North of this ridge and bordering the Nerbudda river is a strip of broken and hilly ground from 3 to 6 miles wide constituting the forests of the Punasa Range. On the North bank of the river and to the East is situated the Chandgarh Range on the continuation of the hills constituting the Punasa Range.

Along the Southern face of the main central branch of the Satpuras runs the Taptee. South of this river rises a higher ridge, forming the southern face of the Satpuras and separating Nimar from the Berar plain. These hills are the highest in the District and constitute the forests of the Burhanpur Range. A deep fertile valley separates these two branches of the Satpuras except for the isolated hill of Samardeo.

3.—Geology of the Nimar District.

With the exception of a fringe of ground along both banks of the Nerbudda in the most northern part of the district the underlying rock is trap. On the surface the trap is more or less decomposed into moorum, and in the valleys forms a fairly deep soil, but on the hills the soil is shallow and stretches of bare sheet rock are frequent.

The excepted tract is composed of Vindhyans with, small outcrops of granite, schists, and gneisses of the Archæan system, and lametas of the Cretaceous system. A considerable portion of the Punasa and Chandgarh Ranges consists of hard almost crystalline Vindhyan sandstones very difficult of disintegration.

On the other hand the outcrops of granite and gneiss as well as the cretaceous limestone-bearing transition rocks of the Chandgarh Range are of loose structure and often conglomeritic. They therefore disintegrate more easily and result in a deeper and richer soil.

4.—Distribution and Composition of Anjan Forest in Nimar.

Now let us see how the configuration of the ground and the underlying rock affects the description of the Anjan. We will first take the main branch of the Satpuras running from West to East. On the extreme West we find the Anjan scattered and fairly plentiful, but proceeding East it becomes less so until we reach the railway at Mandwa where it practically vanishes, hardly a single tree being found throughout the whole of the ridge East of the railway.

Isolated Anjan are found on Samardeo, and it is fairly common at the western extremity of the ridge constituting the Burhanpur Range. It does not grow to any great size in these areas. Proceeding to the areas North of the main central ridge we find the low and undulating hills of the Khandwa Range fairly stocked with Anjan and to the extreme West of this range and extending almost up to the Nerbudda we find a peculiar type of Anjan growth, *viz.*, isolated blocks of practically pure Anjan in the pole stage growing closely and thickly together. Old mature trees are few and far between, and where found are of small dimensions, and have invariably, at some time or other in their life, been pollarded. That the present pole growth is the natural regeneration from a previously existing Anjan forest goes without saying, but the manner of its formation is a subject of much speculation. These Anjan areas appear to be a continuation from the South, northwards, of the areas already referred to at the western end of the main central branch of the Satpuras.

Perhaps even more extraordinary are the areas outside the blocks of Government forest now referred to. The ground is for the most part undulating and much is unfit for cultivation. The Anjan here holds its own tenaciously in spite of all that is done by grazing and felling to exterminate it. Its feathery green foliage is a peculiar feature of the landscape in the hot season long after all

other species are leafless. The average height of a mature Anjan tree throughout these areas may be put at 40 feet and its girth at 3 feet. We now come to the strip of broken and hilly ground bordering the Nerbudda and extending to the extreme North-East of the district constituting the Punasa and Chandgarh Ranges. We find the Anjan throughout this area, but always mixed with other species, never pure, the proportion of Anjan to other species being seldom more than 5 per cent. The patches of pure pole Anjan previously referred to are never found in this area, though natural regeneration is by no means absent. It must be remembered that here we are for the most part off the trap, and in place thereof have Vindhyan sandstones, conglomerates, granite, schists, and limestone.

Most remarkable is the development of the Anjan in this area. Nowhere else in the district does the tree develop such proportion both as regards height-growth and girth. Mature trees with a height of 80 feet and a girth of 6—8 feet are by no means uncommon, with a clean bole of 30—40 feet.

Unfortunately a considerable proportion of these trees when felled are found to be rotten and hollow in the centre. The reason for this seems to be quite unknown and is but one of the many questions regarding this species still requiring elucidation. Having now described the distribution of the Anjan with reference to the physical features and geology of the district it remains to be seen what silvicultural facts governing this distribution can be deduced therefrom. This brings us to a consideration of the "Locality" which, as every Forester is aware, is the sylvicultural term employed to denote the active agencies of soil and climate in their relation to, and combined effect on, forest vegetation.

V.—LOCALITY.

1.—Soil Requirements.

(a) *Chemical composition.*

In the first place we can safely say that the Anjan prefers sandstone, gneiss, conglomerates, limestone and generally rock formations which produce a sandy loam as soil for the roots, to the stiffer and more clayey soil changing into murram which overlies the trap. The former soils afford a better drainage, the under lying rock being as a rule of looser structure, and this is no doubt a factor favouring the Anjan. On the other hand it is very commonly found on trap, but here we come across a peculiar characteristic; it is by no means universal on the trap. To come back again to that main central branch of the Satpuras. The whole of it is trap formation, most of it with a very shallow soil covering bearing the poorest forest growth, and this is particularly noticeable over the western portion of the ridge where the Anjan is found, yet there is a definite limit where the railway crosses this ridge from South to North. There is no obvious reason for this phenomenon. The soil is no poorer to the East, in fact on the extreme East in the Kalibhit Range the soil is as a rule much deeper and some of the best Teak forest is found here. Climate, aspect, rainfall—none of these can be said in this prescribed area to affect the question.

There should be no difficulty in collecting information regarding the distribution of Anjan in other districts and carefully comparing and tabulating the information obtained. This, however, is a work that can only be carried out by the Imperial Silviculturist at the Dehra Dun Research Institute. Such results would very likely throw further light upon the subject, but for the present at any rate we must leave it at this, that the peculiar gregarious nature of the Anjan prescribes in an unknown manner the limits of the species on trap rock.

(b) *Depth of soil.*

The Anjan, as will be described further on, develops a moderately long tap-root and for this reason prefers a deep soil into which the tap-root can easily penetrate. At the same time it cannot be said to be exacting in this respect, for it is commonly found on trap rock where the surface soil is very shallow and it thrives particularly well on the hard crystalline Vindhyan sand-stones which disintegrate with difficulty, and have as a consequence a shallow soil covering. The fact that the Anjan can thrive on shallow soils is no doubt partly due to the extraordinary strength of the tap-root which seems to be able to bore its way even through hard rock down to a permanent water-supply.

(c) *Porosity of soil.*

A porous soil with a well fissured underlying rock is required for the best development of the Anjan, and is clearly illustrated in the growth found on the loose structured formation already described in the Punasa and Chandgarh Reserves of the Nimar Division.

Nowhere on the trap formation, with as a rule an impervious stratum a short distance below the surface, does the Anjan develop to anything like the size it attains on the more loose structured formations.

(d) *Degree of moisture in the soil.*

We know very little regarding the absolute requirements of the species in this respect; but one thing is certain, the Anjan requires a constant and permanent supply of water while young, which supply it takes up through the long tap-root it develops. By this means alone is it able to survive the months of dry and hot weather during which there is no rainfall and the plant is exposed to scorching dry winds causing rapid evaporation from its leafy surfaces. On the other hand from the sapling stage upwards, which so far as our knowledge goes at present, means from the age of about 15 years, the Anjan can put up with very little moisture, and is essentially a drought resisting species. This was very noticeable in Nimar during the drought of 1901 and 1904. Whereas following these droughts such species as *Tectona grandis, Terminalia tomentosa, Lagerstræmia parviflora, Mangifera indica, Buchanania latifolia,* suffered severely all over the Division, not only coppice being affected but also mature trees, in the case of Anjan no damage whatever was done even on the driest soils.

2.—CLIMATE.

(a) *Rainfall.*

The Anjan prefers a dry climate. The average annual rainfall in the localities peculiar to the species varies from 10 to 60 inches. In South India, in the localities mentioned under "Distribution," it enjoys for the most part a rainfall of from 10 to 30 inches. In the Central Provinces it is found where the average rainfall is from 20 to 60 inches. It appears to thrive best with a rainfall of from 20 to 40 inches as obtains in Nimar where, so far as the Central Provinces is concerned, the best growth occurs.

(b) *Heat and aspect.*

Except when quite young Anjan can stand a great deal of heat, and at all stages, a considerable amount of cold. Growing as it does in the dry hot regions of Central India it frequently has a temperature of 112° to put up with during the months of April and May.

The following average mean maximum and minimum temperatures during selected months as recorded at Khandwa since 1875 will give a general idea of the temperature suitable to the growth of Anjan:—

		Maximum.	Minimum.	Mean.
January	...	84°	52°	67·5°
May	...	106·5°	81°	93°
July	...	87·5°	75°	80·5°

Frosts not infrequently occur in these regions in low lying localities, though as a rule they are not severe. No instance has come to our knowledge of Anjan either in the seedling, sapling or mature stage suffering in the least degree from such frosts.

On the other hand seedling Anjan suffers terribly from excessive heat. Curiously enough it is only at this stage of its career that excessive heat appears to have any injurious effect on the Anjan. There is little doubt that the holocaust of seedlings which has been noticed again and again to occur after a good seeding, is due to the excessive heat combined with scorching winds causing rapid evaporation, the seedling being unable, except under the most favoured circumstances, to replace through its root the moisture lost thereby. Aspect would only appear to be of importance in so far as it modifies the temperature to which seedlings are exposed in the hot weather, and protects them from the scorching dry winds. From notes and observations taken in Nimar it would appear that aspects between North and South give the greatest protection to Anjan seedlings and are therefore most suitable to the development of Anjan.

(c) *Light.*

Anjan is on the whole a light demander and cannot force its way through overhead shade. Even the moderate shade afforded by a mature tree of *Boswellia thurifera* is too dense for an Anjan sapling to penetrate through, if once dominated.

At the same time Anjan requires a certain amount of shelter or protection during early youth, though not against light as such. From observations made I am strongly of opinion that shade as a protection to seedlings during the first three or four years growth, against the heat and dry winds of the hot season, is a *sine qua non* in the successful regeneration of Anjan forests.

VI.—SHAPE AND DEVELOPMENT.

A.—Shape.

The Anjan is perhaps one of the most graceful of our Indian trees. Its drooping foliage and branches quivering with the slightest breeze remind us very much of the European Birch tree. During the early part of life the Anjan develops a conical crown; as it approaches full height the crown extends horizontally, the extremities of the branches slightly drooping downwards.

If allowed to grow up in a free position, so that its natural development is not interfered with, the main stem of the Anjan is found divided comparatively low down, branching commencing usually at about one-third of the total height from the ground. On the other hand if grown in a fairly crowded forest, where the growing space is limited, it develops a long cylindrical bole free from branches. The crown is then reduced to less than one-third the total height of the tree.

It must be remembered in this connection that the nature of the soil influences the shape of the mature tree, and that shallow and rocky soils produce only short stems with a tendency to divide early and develop branches.

B.—Development.

1.—Reproductive Power.

We will commence the formation of the flower on the mature tree which is to produce the seed that will develop into the new individual. This may seem like starting at the end, but it is necessary to draw attention to the season of fruiting and seeding as it is of great importance in the development of the seedling. In describing its life history actual statistics and records will be made use of as far as possible.

(a) *Season of flowering and fruiting.*

The Anjan then comes into flower during the rains, that is usually some time in August or September. The fruit is seen on the trees by October, but it is not ripe then, and in fact does not ripen until the following April or May. This is a peculiarity not infrequently met with amongst other species of the same family such as *Dalbergia sissoo*, *Pterocarpus marsipium*, &c.

The seed remains on the tree until May and then falls being scattered by the winds, which are strong at that season of the year, for a considerable distance from the parent tree owing to the light nature of the pod which acts as a wing to the seed.

An important point to note here is that the seed falls when most of the forest fires are over. It therefore suffers very little from this source of danger, so that as a rule every seed which falls from the parent tree is available and ready when the first burst of the monsoon occurs, to do its share in the regeneration of its species.

(b) *Periodicity of flowering and fruiting and quantity of seed produced.*

When the Anjan flowers and fruits, it produces seed most prolifically, probably more so than any other of our valuable Indian timber trees, but these seedings do not occur annually, nor when a seeding occurs is it always of the same intensity. It would not appear that any very definite statistics have been gathered together over a long series of years on this point, but we have collected the following information from the Annual Forest Administration Reports of the Central Provinces and Berar.

The Berar Reports were gone through from the years 1876-77 to 1887-88. The only references to be found were—

(1) 1877-78 was a seed year in Gerumatergaon Reserve (Buldana Division).
(2) 1886-87 was a bad seed year.

The Central Provinces Reports were gone through from 1887-88 to 1906-07. The references found were—

(1) 1898-99 was a bad seed year.
(2) 1899-1900 was a good seed year in Chanda and Nimar.
(3) 1902-03 was a seed year in Gerumatergaon Reserve (Buldana Division).

A note of more value than any of the above in the report for 1899-1900 is made by Mr. Fernandez and is worth recording *verbatim*:—"It may be convenient to record here the years in which Anjan has seeded in Nimar since the writer of this report joined the service—1874, 1879, 1884, 1889, 1893, 1899."

Here we have some definite figures to go on. To these we can now add the year 1904-05. Accepting the above figures as those of recorded observations we find that the Anjan reproduces itself by seed almost regularly every five years; from 1874 to 1904 there were in Nimar seven good seed years, and in only one year, *i. e.*, in 1893, was the five-year period deviated from.

The actual year in which a seeding takes place is not however necessarily the same in two localities and it may vary within very prescribed limits. To take a case in point, we have the year 1877-78 as a seed year in the Gerumatergaon Reserve of the Buldana Division of Berar and again the year 1902-03. We shall probably not be far wrong if we fit in the intervening seeds years as 1882, 1887, 1892, 1897, and the fact that 1902 was recorded as a seed year lends strength to the supposition. It will be seen that this cycle of seed years comes in between that recorded for the Nimar Division. The Buldana Division and Nimar are not very far apart, but to take a more prescribed area we may mention that this year none of the Anjan in the Khandwa or Punasa Ranges of the Nimar Division seeded, while all the Anjan trees planted along the roads in the Civil Station of Khandwa, and there are a considerable number, flowered and seeded most profusely.

(c) *Effect of drought on seeding.*

It is a well-established fact that a year of drought often induces profuse seeding. This is perhaps commonest with the bamboo, *Dendrocalamus strictus*, but it would appear to be the case also with the Anjan.

Writing in the Forest Administration Report for 1899-1900 Mr. Fernandez says: "Similarly, the drought was the immediate cause of the seeding, always gregarious, of the Anjan."

We certainly have the following facts to uphold this opinion. The rains of 1896, 1899 and 1904 were very scanty throughout the Province, while in two instances out of three, *viz.*, 1899-1900 and 1904-05, good seedings occurred in Nimar. Again, the rainfall as recorded at Khandwa during 1907 was only 17 inches as against a normal average of 30 inches. May not this have had something to do with the abundant seeding of the Anjan planted along the roads in the Civil Station as already mentioned?

2.—The Seedling.

(a) *Development during first year.*

We have described the process and periodicity of seeding of the mature tree and have reached the stage where the seed lies scattered on the ground in the early days of June waiting for the rain which is to quicken it into life.

We will now take up the story making use of actual observations to emphasize our facts.

In May 1908 the seed from the Anjan trees planted along the road running past the front of our bungalow in Khandwa was scattered by the wind in large quantities over an open space of compound. The soil here consists of a dry sandy loam varying in depth from 6—18 inches resting on hard moorum soon passing into solid trap rock. The first shower of rain fell on the 13th June followed by over one inch on the 16th and smaller amounts on the 17th and 20th.

For easy reference the table rainfall for the months of June and July 1908 as recorded at Khandwa are here appended, as we shall have to refer to them frequently :—

Table of Rainfall at Khandwa during June and July 1908.

JUNE.

Date ...	1—12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Amount of rain in inches...	*Nil.*	·06	...	...	1·05	·21	...	...	·10	...	...	...	...	...	·61	1·28	1·0	·27	1·22

JULY.

Date ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Amount of rain in inches..	1·31	...	·18	·08	·02	·25	·15	·02	·13	·50	·62	·22	·23	·03	·02	...	·03
Date ...	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	...	...
Amount of rain in inches ...	·03	...	·06	·05	·15	...	...	...	...	...	...	·60	·82	·28	*Nil.*	...	...

i.—*Germination.*

The seed lay on the ground during these preliminary showers, but to all outward appearance was not affected thereby. Then came nearly a week of dry hot weather, until on the 26th the rain began again in earnest. Up to this date the seeds had shown no signs of germination, but, as a matter of fact, they had been taking in the moisture and the seed was swelling within its seed coats and preparing itself for further development. Then came 6 days of continuous rain during which germination was in active progress, with the result depicted in Fig. I.

This figure represents the stage of development on the 2nd July. The cotyledons are seen bursting or already burst out from the seed coats and the radicle well on its way to forming a tap-root. Let us now turn to Fig. II which shows us the development a week later—on 8th July. A reference to the table of rainfall will show that there was continuous rain, though light, between 2nd and 8th July. The soil, however, was well saturated with moisture and development was very rapid. The tap-root is already 5·75 inches in length and two leaves are almost fully formed. It should be noted here that the examples taken were typical of the hundreds of seedlings that were germinating all round and that no exceptionally developed specimens were chosen.

We will now pass over an interval of three weeks which brings us to 1st August. Rain fell every day in small quantities except on the 16th, 22nd to 27th and 31st. Our typical seedling has now developed into the specimen depicted in Fig. III. Four leaves are fully developed and the beginning of a fifth.

ii.—*Development of the tap-root.*

The tap-root, however, is the point that interests us most. That in the figure was found to be 9·80 inches in length. For purposes of comparison 8 typical seedlings were completely dug up with the results enumerated below :—

Depth below the surface at which hard moorum was met with.	Serial No.	Length of tap-root in inches.	Remarks.
8 inches	1	9·80	Fig. III.
„	2	8·38	Incomplete, tip broken.
„	3	11·33	Do. do.
„	4	9·20	
„	5	9·64	Last 2·28 inches were in hard moorum which was with difficulty broken away.
10 inches	6	11·15	
16 inches	7	16·10	
„	8	6·51	Fig. IV. At 2 inches the root met an obstruction of a piece of broken tile, and divided into two branches. Soil mixed with stones and pieces of broken tile.

The extraordinary power of the tap-root is being able to pierce through what appeared to be almost solid rock was the most noticeable feature in the above experiment.

Fig. IV is of interest as showing the manner in which the tap-root avoided and worked round obstacles which it could not pierce. The breaking up into two main branches is exceptional and was only brought about by the stony nature of the soil.

On 1st September, that is a month later, we again examine our seedlings. Rain has been neither excessive nor deficient. The first thing that strikes us is that practically no further development has taken place above ground, while below ground the tap-root has only made an appreciable advance, where the soil is so deep that growth in length is easily accomplished. Otherwise a slight thickening of the tap-root is noticeable.

In exceptional cases a difference is seen and it will be of interest to quote an example. A particularly healthy and well developed seedling was dug up. The part above ground measured $5\frac{1}{2}$ inches and had nine leaves developed (compare this with Figs. III and IV), but the length of the tap-root, when laid out straight, measured only 12·75 inches, and the end was not at this depth below ground. This particular example was dug up with the expectation that a particularly long tap-root would be found, and a good depth of soil, quite the contrary, however, was the case. The soil was found to be very shallow hard moorum being met with at 6 inches below the surface. From this point the root turned off at a sharp angle seeking fissures which it could penetrate and after numerous twistings and turnings came to an end at only 10 inches below the surface. The most remarkable point was the exceedingly hard nature of the moorum the root had penetrated requiring a strong pick to break it away. The tap-root in this instance had developed numerous side shoots and was strongly developed.

This was no doubt an exceptional case, but none the less interesting.

The first year's period of growth being now at an end, we need not delay and all that it is necessary to note of the period up to the second rains is that by March of the following year most of the seedlings have lost their leaves and by the beginning of June hardly a trace of the thousands of seedlings that were so conspicuous during the rains is to be seen.

(b) *Development during second year.*

We must now pass on from the seedlings which we have watched germinate and make their first start in life to the typical seedling in its second year. We have had to fill in the gap from the end of the first season of growth through the hot season to the beginning of the next rains from general observations. Let us start describing the second year's development by imagining a plot of ground, say one yard square, on which we counted 50 seedlings last year. Just before the commencement of the second rains we examine this plot and with difficulty we count 15 little brown stalks which we take to be all that remains of our 50 seedlings. After the first month of rain we again count and are surprised to find no less than 30 seedlings easily distinguishable by their one or two leaves. At first sight it appears as though new seedlings have sprung up, but on closer examination we find this is not the case. What has really happened is that the first shoot has died down entirely while the root has survived and, with the fresh lease of life induced by the rains, has sent up a fresh shoot. The chief interest here is where does this fresh shoot arise from? For the answer we must turn to Figs. V—VII. Fig. V represents three actual two-year old seedlings.

i.—*Cotyledonary buds.*

A glance at the points marked *A* on Fig. V disclose on either side of the ascending stem a small bud. This point *A* marks the position where the cotyledons are attached in the seedling. The buds are best known as cotyledonary buds. In Fig. V it will be noticed that these buds are dormant, the main and original stem only having developed.

Now let us turn to Fig. VI-(*a*) and (*b*). In VI-(*a*) we notice that the main stem has died down and in its place one of the side cotyledonary buds has developed. Fig. VI-(*b*) shows a case in which the main stem has continued to develop, but in addition one of the side cotyledonary buds has commenced developing and then again died down.

In Fig. VII-(*a*) and (*b*) we find that both the cotyledonary buds have developed. In Fig. VII-(*a*) and (*b*) the central stem has died down, and has been replaced the following year by the development of one of the cotyledonary buds, which in its turn has died down to be again replaced the third year by the remaining bud. It not infrequently happens that both side buds develop after the main stem has died down the first year, but one of these only finally becomes the leading shoot.

This peculiarity explains the phenomenon already alluded to, *viz.*, the few number of seedlings to be found on the ground just before the monsoon breaks and the large increase in their number after a month of rain.

ii.—*Development of the shoot.*

The next point to have our attention is the size and development of the second year's shoot. The most marked thing about it is its extremely small size, both as regards stem and leaves when compared with the first year's shoot. It would appear that the plant had determined to concentrate all its energies on the development of the root system. Figs. V—VII give some idea of the small size of the second year's shoot when compared with Figs. II—IV.

iii.—*Development of the root.*

As regards the tap-root development would appear to be more in the direction of circumference than in length. Figs. V and VI may be compared with Figs. II—IV in this respect. The actual recorded length of two years' old seedlings was 16 inches and 27 inches respectively. This, considering that seedlings in the first year attain a length of 20 inches, shows that comparatively little advance in the length of the tap-root is made during the second year.

(c) *Development during third year.*

i—*Root development.*

Passing on to the third year we again find that further development has been very slight and gradual. Fig. VIII depicts three 3-year old seedlings dug up on the 6th August 1908. They had therefore completed three years of growth and were just entering on their fourth year. The figures are drawn to scale, life size. The lengths of the tap-roots were 20·30 inches, 23·30 inches and 30·31 inches respectively. In judging of these lengths and comparing them with the measurements recorded of the 8 seedlings dug up in Khandwa on 1st August 1908 it is necessary to take into consideration the soil in which the seedlings were growing in both cases. In the case of the first year seedlings we found hard moorum at a depth varying from 8 to 16 inches. The three-year old seedlings, however, were growing in soil consisting of 6 inches of deep loam, 6 inches of a mixture of loam and moorum, 18 inches of loose disintegrating moorum with harder portions in between.

There were thus 24 inches of easily penetrated soil for the tap-roots to grow down into.

It should further be noted that the second-year old seedling, the length of whose tap-root was recorded as 27 inches, was dug up within a foot of the spot from which the three-year olds were taken, and therefore in similar soil.

From the above-stated facts it is clear that there has been very little development in length since the first year and probably none at all between the second and third year.

On the other hand there has been a decided thickening of the tap-root as may be easily seen by comparing Figs. II, III, V and VIII.

There is also a tendency of the tap-root to lose the side rootlets near the surface and develop more deeper down. This is no doubt connected with the supply of moisture in the soil, the upper layers being naturally drier than the deeper.

ii.—*Shoot development.*

So far as the shoot is concerned we have exactly the same conditions as we found in the second-year old seedlings. It is almost impossible to distinguish with any degree of accuracy between a two and three-year old seedling by its size. Comparing Figs. IV and VIII-(*a*), except for the cotyledon, who would imagine that Fig. IV represents a seedling one month old and Fig. VIII-(*a*) a seedling tree years old?

(d) *Development during fourth and subsequent years.*

This brings us to the end of our observations on the seedling. From the fourth year onwards we are much in the dark as regards its development until we find if a healthy sapling shooting up rapidly 2 and 3 feet in a year. All we know at present is, that those seedlings which get through the first two or three years of their existence, and they are few compared with the numbers that originally germinated, drag on an existence which appears to consist mainly of root development, the part above ground hardly increasing in height at all and only very gradually developing into a little much branched bush 6 inches to 12 inches in height. Then suddenly a change seems to come, a leading shoot forms and, provided it is not interfered with, starts growing in height a foot or more each year. The chief point to elucidate in this stage of the development is how long does it take the average Anjan plant to reach the stage where height-growth commences. From general observations we believe the length of time to be certainly not less than 10 years and probably considerably longer. Continuity of observation would soon set this point at rest.

(e) *Summary and conclusions.*

It may be well to halt here a moment and enumerate the chief facts we have learnt regarding the early stages of development of the seedling. They may be summarized as follows :—

1. The seed requires to be subjected to a thorough soaking for some time before germination sets in.
2. Growth is very rapid as soon as germination sets in, the principal development being in the formation of a tap-root.
3. The length of the tap-root depends on the nature of the soil it has to traverse, deep loose soil favouring a long tap-root and *vice versâ*.
4. This tap-root may attain a length of 3 feet depending on the nature of the soil.
5. The first year's growth is almost completed within the first two months of rainfall, subsequent development being very slight.
6. The majority of the seedlings die down at the end of each cold weather and produce fresh shoots the following rains by development of cotyledonary buds.
7. The second and third year shoots are not nearly so vigorous as the first year's.
8. Root development after the first year is almost entirely in the direction of circumference.

3.—THE SAPLING.

(a) *Its appearance.*

We must pass over the unknown interval of ten or more years, and make a fresh start with a typical sapling which has just commenced its principal height-growth. In the natural forests with which we have to deal and especially where grazing has been at all prevalent our typical sapling has a very bushy and much branched base from 1 to 2 feet in height out of the centre of which rises a distinct leading shoot. It was intended to add to the interest of this paper by reproducing some photographs of typical saplings and generally of Anjan growth at various stages of its development, but unfortunately time and space did not permit of this being done. Later it is hoped to reproduce this paper with further additions.

(b) *Shedding of branches.*

To return to the leading shoot a close examination of it will show at intervals along its length distinct annular marks, or rings usually in the form of a slightly raised ridge. These marks arise in the following manner. Towards the end of the season of growth, about March, a portion of the year's growth is shed much in the same way as leaves are shed. Just as a leaf scar arises from the shedding of a leaf so does a scar result from the shedding of the woody shoots and branches. In April and May the ground under Anjan trees will be found to be littered with small twigs and branches, which at first sight appear to have been broken off, but a close inspection shows they have literally been shed like leaves.

On the surface of the scar so formed a bud develops, which bud the following year grows out into the new year's shoot. There is thus a distinct

ridge or scar left at the point where the branch has been shed and these ridges can be traced back on the sapling for several years. From what has been said it is clear that each ring represents the end of a year of growth, and the space between two such rings represents therefore the height-growth for that year.

These rings gradually become effaced as the sapling increases in girth, but from 4 to 6 years growth can usually be fairly accurately deciphered.

(c) *Rate of height-growth.*

From these rings we find that the average rate of height-growth of a normal Anjan sapling from a height of 3 feet onwards is from 9 to 12 inches a year. How long this rate of height-growth continues and whether it still further increases or afterwards decreases are points still awaiting elucidation. As the sapling shoots up the bushy appearance at the base disappears and by the time the sapling is about ten feet high it is practically clear of all branches in the lower portion. The bark of the sapling is then smooth and almost a silvery white and a patch of advance growth of young Anjan presents at that time a very conspicuous appearance.

(d) *Age of a 10-feet sapling.*

It may be interesting to calculate, from what has been said, the average age of a sapling 10 feet high. We start on the assumption that when height-growth set in the sapling was 3 feet high and 12 years old. A further growth of 7 feet at an average rate of 10 inches a year would occupy another 8 years, thus bringing up the age of the sapling at that height to 20 years.

As the sapling advances in growth to the pole stage, the only outward alteration in its appearance is the gradual change in the character of the bark, which becomes dark grey and rough with irregular vertical cracks.

4.—GROWTH FROM THE POLE STAGE TO MATURITY.

(a) *Height-growth.*

We have been unable to obtain any statistics regarding the rate of height-growth from the pole stage to maturity, but it would appear that the growth is gradual and long maintained.

The factors of the locality have of course a decided effect on the height-growth, more especially the soil. Under the best conditions Anjan frequently reaches a height of 80 feet and more. Brandis says "occasionally 120 feet. On the shallow soiled trap formations it seldom attains a height above 60 feet."

(b) *Volume growth.*

From our own observations we have found the rate of growth to be distinctly slow on the average 12 rings per inch of radius.

Statistics of some planted trees of known age on the Kistna Canal, Madras Presidency, give an average, however, of 8 rings per inch.

For comparison we give these figures, which are quoted in Gamble's "Manual of Indian Timbers," alongside with the figures, from a tree of average growth growing on the sandstone formations in the Punasa Range of the Nimar Division:—

Kistna Canal, Madras.		Punasa Reserve, Nimar.		Remarks.
Age.	Diameter.	Age.	Diameter.	
5	2·04	5	·36	
10	3·23	10	1·02	
15	4·54	15	2·00	
20	6·10	20	2·60	
25	7·35	25	3·32	
30	8·43	30	4·18	
35	9·43	35	5·06	
40	10·39	40	6·22	
45	11·33	45	7·06	
50	12·26	50	7·88	
55	13·18	55	9·22	
		60	10·18	
		70	11·92	
		80	13·28	
		90	15·24	
		100	16·80	
		110	18·62	

As regards the Nimar sample tree, the growth of the heartwood only was calculated, the rings in the sapwood being too indistinct. As the sapwood measured 2·20 inches on the radius, at the same rate of growth this would mean another 26 rings, so that the age of this tree was about 136 years. The Madras trees show a much more rapid rate of growth than those in Nimar, especially during the young stage, the diameter growth of five years being quite phenomenal when compared with the seedlings illustrated in Fig. VIII. The difference, however, may be due to the locality on the banks of a canal with a permanent water-supply the whole year round keeping the seedlings from dying down each year, thus ensuring an uninterrupted growth.

Volume growth continues for a very long period on good soil, judging by the size of the old mature trees found in the Punasa Reserve. Girths of 8 feet are not uncommon and occasionally trees up to 10 feet in girth are come across.

(c) *Duration of life.*

Judging by the size of some of the largest trees in the Punasa Reserve the Anjan must be a very long lived tree.

Assuming on an average rate of growth of 12 rings per inch of radius, a tree of 9 feet girth, after allowing say 2 inches for the thickness of the bark, will represent an age of not less than 400 years. Trees of such age appear quite healthy as regards their outward appearance, but a very large proportion are found to be unsound when felled; whether this is merely the result of extreme age or whether other factors are at work to produce this unsoundness we are unable to say.

Probably the Anjan tree reaches maturity and is at its best at an age of 200 years on the best soils, and at an age of 100 years on poor shallow soil.

5.—Coppice and Pollard Growth.

In Nimar Anjan coppices and pollards extremely well, and to a comparatively late age. Its capability of pollarding is particularly marked and to this and to the value of the leaves as fodder may be attributed the larger number of old pollard trees that are still found all over the Anjan areas in Berar, Nimar and elsewhere. On account of the very hard nature of the timber it is the custom in Nimar to fell large Anjan trees over 4 feet in girth at a height of from 3—4 feet from the ground. Such stumps though anything from 200 to 300 years old almost invariably send up strong pollard shoots which develop into fair-sized poles. Trees of this age, however, if cut flush with the ground, do not, as a rule, produce coppice shoots.

VII.—CONCLUSION.

We have now traced out the gradual development of the Anjan tree, from the seed up to maturity, but are conscious of many gaps in its life-history still requiring to be filled up. If this paper serves to bring forward information to fill up those gaps it will have fulfilled its immediate purpose. It was intended when this paper was commenced to follow up the life-history with what is of chief interest to the Forester, *viz.*, the formation of Anjan forests, their tending and the treatment required as well as a discussion of the controversial side of the question such as the effect of grazing on Anjan regeneration, etc., concerning which numerous observations have been made by the writer.

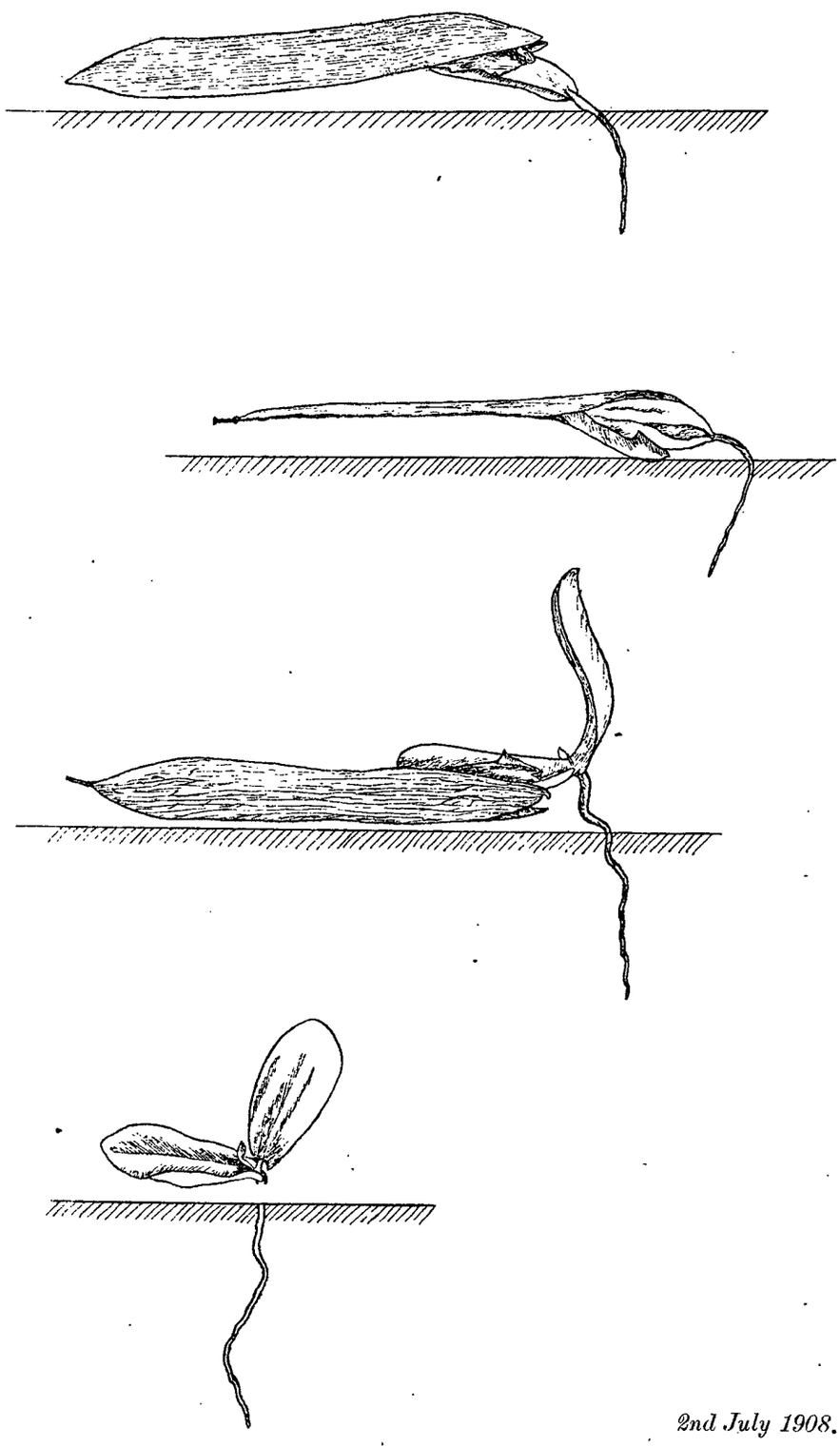
Want of time and space, however, have rendered this impossible in the present paper, which must therefore be looked on merely as an introduction to a wider and more discursive review on the sylviculture of the Anjan in the broader aspects which assail the practical forester.

It is hoped to include in this further review any information which the discussion of this paper may bring forth and to add illustrations of different types and phases of Anjan forests.

CENTRAL PROVINCES FOREST CONFERENCE, 1908.

THE GERMINATION OF HARDWICKIA BINATA—D. O. WITT.

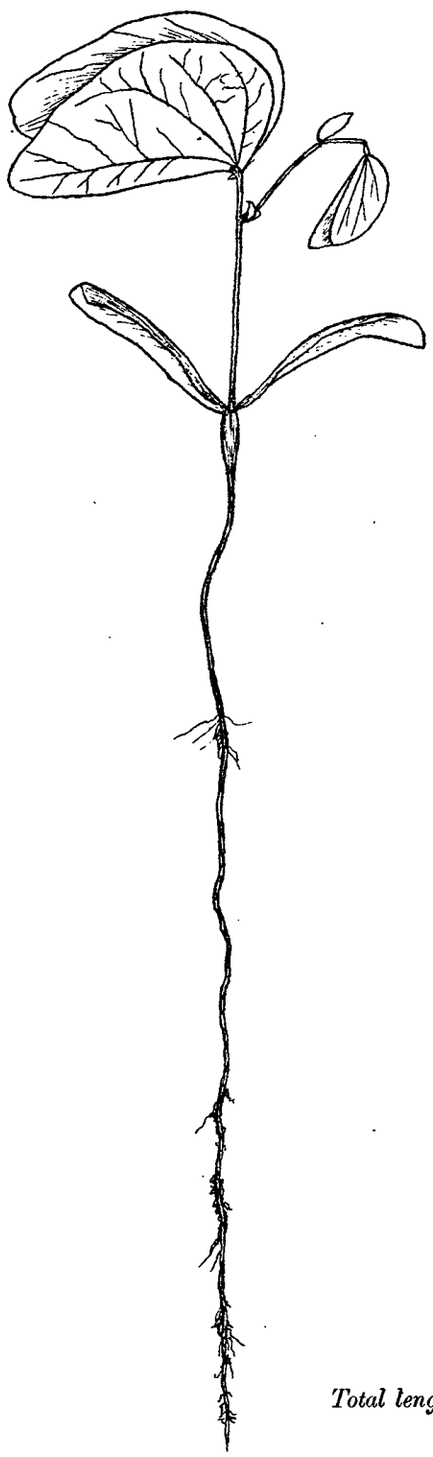
Fig. I.



2nd July 1908.

Regd No. 2412 F., 08—H.—300.

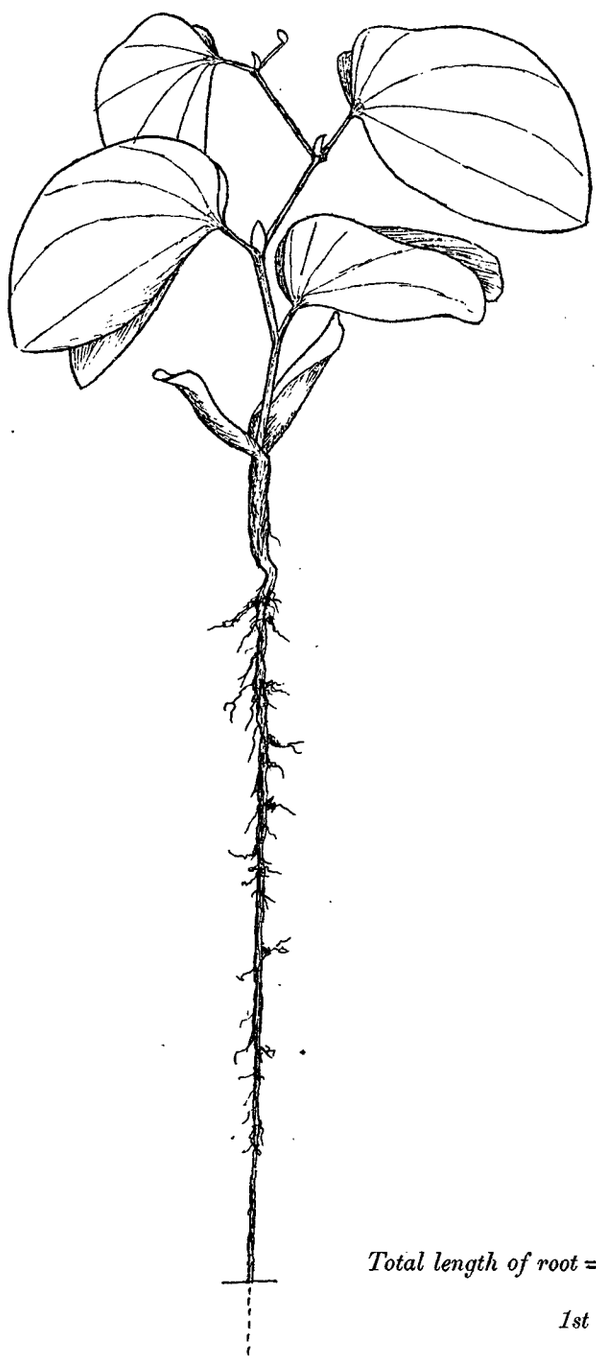
Fig. II.



Total length of root=5·75 in.

8th July 1908.

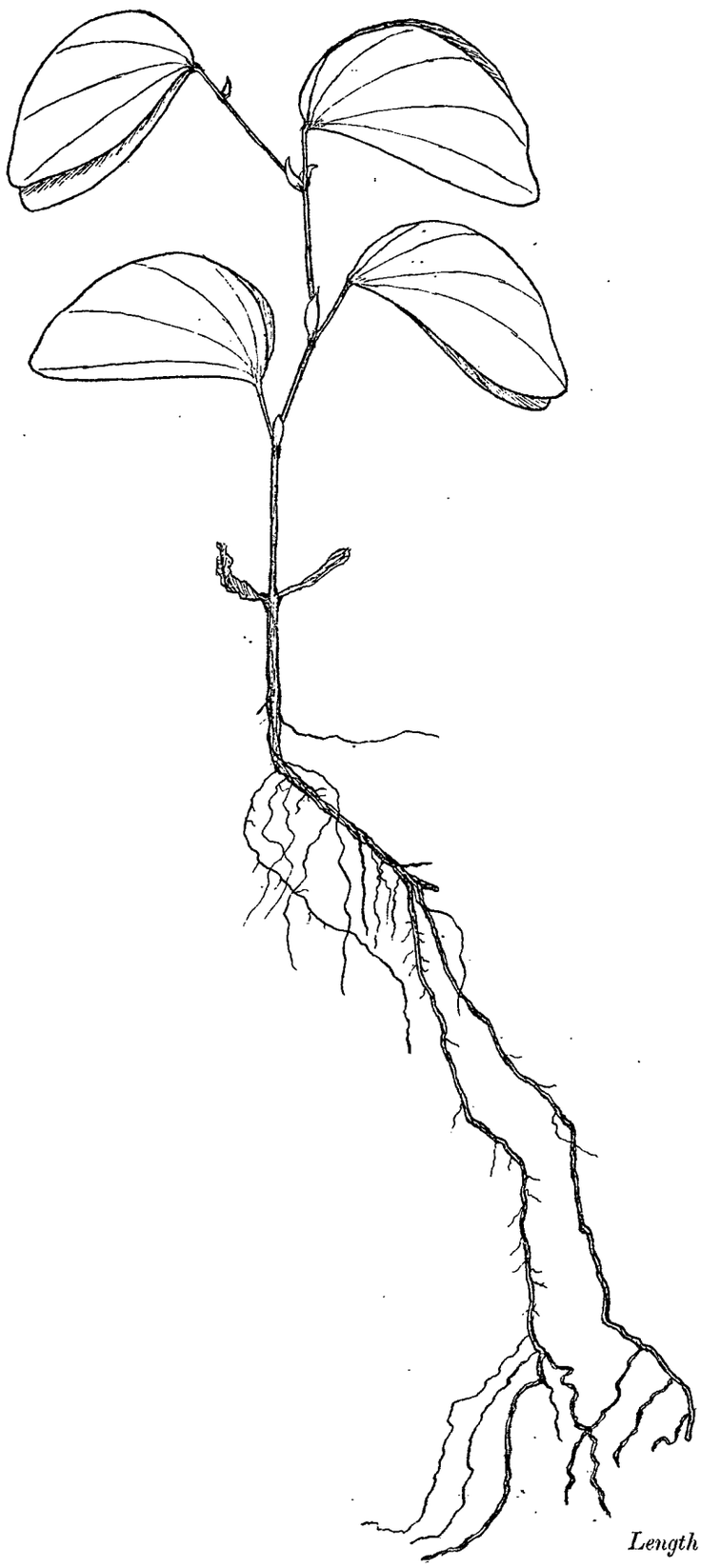
Fig. III.



Total length of root = 9·80 in.

1st Aug. 1908.

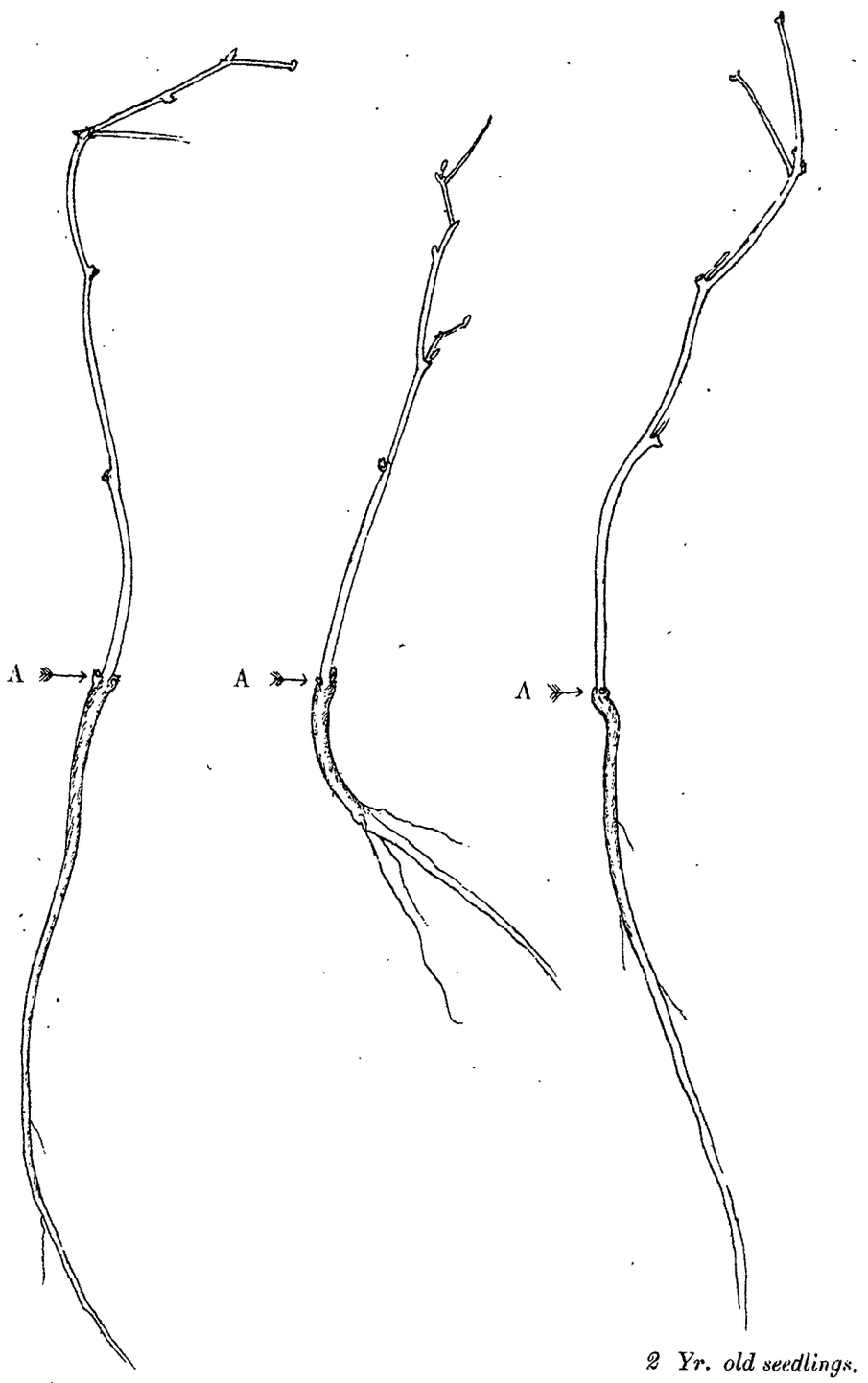
Fig. IV.



Length of root = 6·51 in.

1st Aug. 1908.

Fig. V.



2 Yr. old seedlings.

THE DEVELOPMENT OF THE SEEDLING OF HARDWICKIA BINATA—D. O. WITT.

Fig. VI.

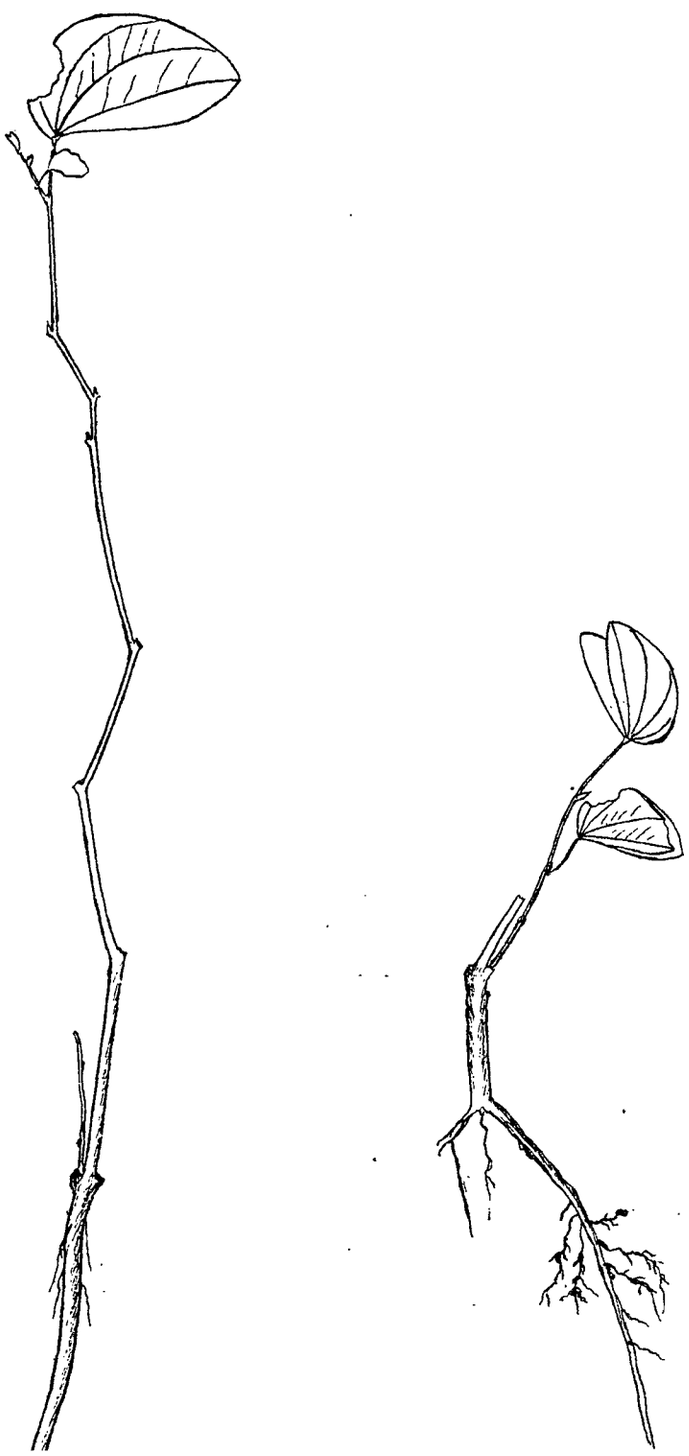
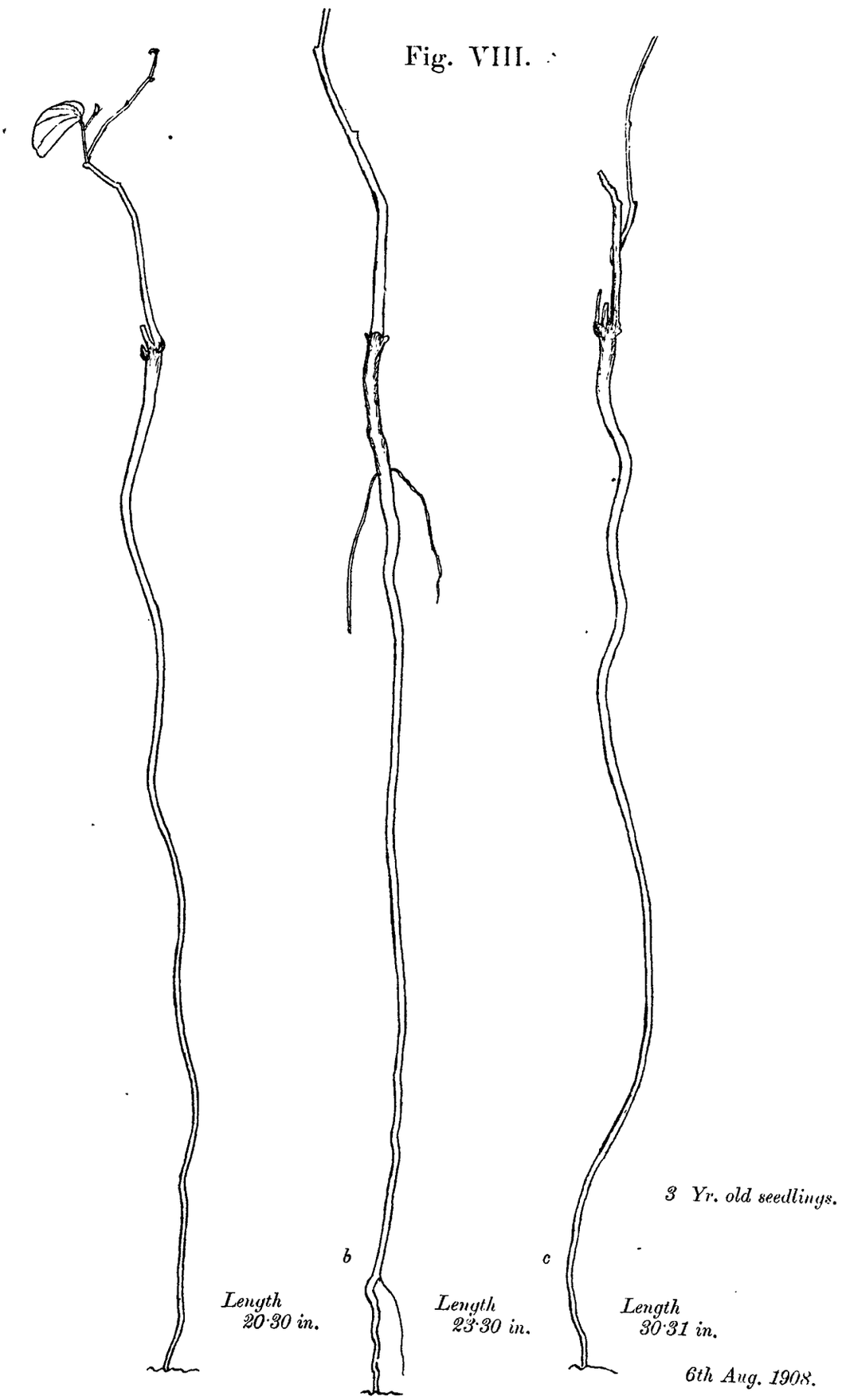


Fig. VII.

3. Yr. old.

THE DEVELOPMENT OF THE SEEDLING OF HARDWICKIA BINATA—D. O. WITT

Fig. VIII.



3 Yr. old seedlings.

6th Aug. 1908.

DISCUSSION ON MR. WITT'S PAPER.

With regard to the distribution of *Anjan*, Mr. Newman stated that it was found on poor rocky soil in the Khandesh District in Berar, and Mr. Rogers that it was found on the outer ranges of the Satpuras in the south-western portion of the Melghat Taluq of the Amraoti District: in the Ambarbarwa Reserve, on the southern slopes of the Satpuras, in the Buldana District adjoining Khandesh, where it forms almost pure forests, and on the northern slopes of the Ajanta hills in the Buldana and Akola districts.

Mr. Shrinivasalu drew attention to the peculiar susceptibility of this species to damage by grazing. The leaves are greedily eaten by cattle, and before the forest were protected, the trees were regularly lopped to provide fodder after the other sources of supply were exhausted. The tree is only leafless for a few weeks, and the young leaves appear at the commencement of the hot weather, when there is very little, if any, grass available: in consequence seedlings and saplings are regularly browsed by all kinds of animals. In areas which have been closed for five years *Anjan* seedlings are beginning to appear and from experiments made last year it appears that if these seedlings are to persist, cattle can be only admitted into *Anjan* forests at the rate of 1 to every five acres during the rainy season and that they should be withdrawn soon after the rains cease.

Mr. Rogers said that he had noticed the recuperative powers of browsed *Anjan* in the Nimar Division in 1907, when inspecting a coupe in the Punasa Range, which had been cut over and closed to grazing for five years. The browsed saplings had all developed leaders, and an examination of these showed that the leaders were five years old, showing that the upward growth coincided with the closing of the area to grazing. They are now out of reach of cows and bullocks and will undoubtedly develop into trees.

Mr. Caccia asked Mr. Witt if he considered that the dying back of the shoots of the seedlings for several years in succession was normal, or whether it was due to exceptionally unfavourable conditions. Mr. Witt said that so far as his observations went, the seedling shoots invariably died back, and only persisted when the root had developed sufficiently, to allow of its throwing up a shoot which was strong enough to exist through the long dry hot weather. Mr. Rogers said that seedlings in sheltered localities did not always die back the first year. This observation is borne out by the sample plots under seed bearers near Buldana instituted four years ago. Seedlings of different sizes are found in these plots which resulted from one and the same seed year. It would appear that the seedlings of *Anjan* usually die back for several years, but that where they are sufficiently sheltered, they do not always do so.

It is evident that the dying back of *Anjan* requires to be studied further before any definite conclusion can be come to, as to whether the dying back has any direct connection with the period of vegetative activity, and in this connection information is required as to the dates of the first appearance and shedding of the leaves of both seedlings and trees of this species.

Mr. Caccia then asked if anything definite was known about the further development of the tap root of *Anjan* which is such a prominent feature of the young seedling. It would be interesting to know if it persisted and developed with the tree as is the case in *Sal*, or became insignificant was replaced by strong side roots as in *Teak*. Mr. Witt had no very definite information to offer on this point, but was inclined to believe that from the fact that *Anjan* trees growing on black cotton soil were frequently thrown down by the wind that the tap root did not continue to develop. Mr. Shrinivasalu stated that in the case of some *Anjan* trees dug up on the site of the bund of the Parkheir tank (Buldana District) that the tap root persisted to a depth of 25 feet, which seems to show that they have in prominent tap root. The question of the development of the tap root in *Anjan* therefore requires to be further investigated. *Resolution No.* 29 was then framed and passed by the Conference and Mr. Shrinivasalu's paper on *Babul* was taken up.

RESOLUTION PASSED ON MR. WITT'S PAPER.

Resolution No. 29.—Resolved that experiments be carried out to study the dying back of *Anjan* seedlings in connection with the period of vegetative activity. That the dates when the leaves first appear and are shed in different localities, extent of dying back, as well as the nature of the root system, should be recorded and compared. That Forest Officers should be asked to conduct the same experiments with regard to Teak, Saj, Sal, and any other species, and to communicate their observations at the next Conference.

SECTION VII

(1)—PAPER ON THE DISTRIBUTION AND CULTIVATION OF *ACACIA ARABICA* (BABUL) IN BERAR.

(2)—DISCUSSION ON THE PAPER.

(3)—RESOLUTIONS PASSED.

PAPER

ON

THE DISTRIBUTION AND CULTIVATION OF *ACACIA ARABICA* (BABUL) IN BERAR

BY

S. SHRINIVASALU NAYADU, Esq.,

Extra-Assistant Conservator of Forests, Buldana Division, Berar Circle, Central Provinces.

THE DISTRIBUTION AND CULTIVATION OF *ACACIA ARABICA* (BABUL) IN BERAR.

General description of the tract.

Berar at present consists of the four districts of Amraoti, Yeotmal, Akola and Buldana. Each of these, except Amraoti, constitutes a Forest Division of the same name. The Amraoti District contains two Divisions—the Melghat Division and the Amraoti Division. There are three main natural divisions of Berar, *viz.*, the Gawilgarh hills, part of the Satpura Range (the Melghat) on the North, the Ajanta hills range (the Balaghat) on the South, and a broad valley (the Payanghat) between these two ranges. These three tracts comprise roughly 1,631, 7,859 and 8,200 square miles respectively. The Melghat Division contains the Gawilgarh hills. The Amraoti Division lies in the Payanghat portion with the exception of a few small tracts presenting the same characteristics as the Balaghat. More than four-fifths of the Yeotmal Division is in the Balaghat, only the Wardha and Bembla valleys form part of the Payanghat portion. The Akola and Buldana divisions consist of the Balaghat and the Payanghat in about equal proportions.

Underlying rock and soil.

Generally speaking, the underlying rock throughout, consists of the Deccan trap, with a variable depth of black cotton soil on the top. In river valleys and on the sides of streams deposits of silt are frequent. In the Payanghat there is a deep deposit of alluvium, often extending to a depth of 150 feet. Black cotton soil in this place occurs always at the surface with yellowish calcarious loam underneath. Very often this layer appears at the surface, and it is then not as favourable to tree growth as when the black cotton soil is uppermost. The alluvium especially in the heart of the Payanghat, *viz.*, along the Purna, contains a good deal of soda salts.

Position of Berar as to rainfall and humidity.

The whole of Berar comes within the dry zone described in Sir Dietrich Brandis' pamphlet—"The Distribution of Forests in India." This zone has a rainfall varying from 15 to 60 inches and is eminently suited for Babul. In Berar the rainfall varies from 30 in the Payanghat to 58 inches in the Gawilgarh hills, the Balaghat getting an average of 38 inches, and is therefore not excessive for Babul; nor does the humidity of the atmosphere continue beyond the rainy season. Thus the chief factors that influence the distribution of Babul in Berar are the situation and the soil and the altitude.

Situation and altitude.

The Gawilgarh hills average a height of 3,400 feet with steep slopes and contain shallow soil with a substratum of trap rock. In the ravines and valleys of these hills though deeper soil may be found a waterless substratum and frosts are prejudicial to Babul. Thus this portion of Berar is entirely unsuited for the growth of Babul. The Balaghat contains extensive undulating plateaux which vary in height from 1,588 feet to 2,190 feet. Babul exists here as a scattered tree or in small groups on banks of streams, in lands set apart for public purposes close to village sites, or amidst cultivation, wherever the soil is deep enough to retain moisture, or the water-holding substratum is close to the surface and there is sufficient immunity from frosts and weed-growth. Babul here is fairly common, as it is difficult to pass any considerable stretch of country without encountering a Babul tree. The Payanghat however contains practically nothing but Babul. Here the water-bearing stratum is very deep, but the surface alluvium holds sufficient moisture, and frosts are practically unknown. Moreover the existence of soda salts to a large extent, in the soil favours the growth of Babul and its few associates to the exclusion of other trees. Thus while it is possible to grow Babul woods in many places in the Balaghat, the Payanghat is best suited for raising Babul crops and most of the State "Babul bans" therefore exists here.

The State Babul forests at present are as follows :—

		Acres.
Amraoti Division	... ...	7,068
Akola ,,	... ...	4,067
Buldana ,,	... ...	3,467
Yeotmal ,, (approximately)	...	1,000
Total	...	15,602

The great demand for land for cultivation in the black soil country has naturally limited the formation of State Babul bans. For this reason, and in view of the great value and importance of the tree to agriculturists it behoves us to attempt Babul cultivation wherever favourable conditions occur. Land set apart for public purposes such as *gothan* (cattle-stand), *khalwadi* (threshing floor), &c., commonly contain a considerable amount of Babul growth. Indeed in the Balaghat tract it is generally these lands that contain Babul when the country around has little or none. These lands therefore form an important source of supply, though owing to excessive grazing and browsing that must take place in them, they cannot at present be systematically worked.

The distribution of Babul in Berar is shown in the map attached to this paper. By a rough computation the area of such land capable of growing Babul is probably about 12,500 acres. It is impossible to gauge the area of occupied lands under Babul outside the State-forests. It does not pay the cultivators to set apart land specially for growing Babul. Hence the Babul in private lands is found on boundary strips and nala banks which cannot be brought under cultivation. It is probable that these strips amount at present to at least as large an area as State-forests.

Of the State area, Bhongaon and Loni forests form compact blocks of 2,014 and 1,047 acres respectively in the Buldana and Akola Divisions, and these blocks are under a sanctioned working plan. The remaining area are scattered blocks consisting frequently of single survey numbers (fields). Babul *bans* (woods) exist in the vicinity of the Purna in the Buldana Division and the Akot Taluq of the Akola Division. In other places, *viz.*, in the Amraoti Division and the Murtizapur Taluq of the Akola Division the blocks are small in extent and much scattered.

Varieties. There are three distinct varieties of Babul—Telia, Kaora and Ramkati.

The name Telia is used to imply smoothness, from the notable paucity and insignificance of its spines as compared with those of the Kaora. The fact of its wood being more close-grained than either Kaora or Ramkati has also given rise to the name. It has a loftier and sparser crown than Kaora, and its pod is moniliform, while that of Kaora has little or no constrictions between the seed. The bark of the Telia is less deeply cracked than that of Kaora. Kaora means in Marathi "Mad." The abundance of conspicuously stout spines on this tree and its massive crown seem to have given rise to the above name. Ramkati develops a straight and tall trunk with cupressiform branches. These branches being always thin, the trunk is pre-eminently conspicuous. On account of this the tree is known as Rama's "Kati" (wand). This mythological interest has given rise to a prejudice against the use of this tree for building and other purposes, by the Hindus who even refuse to fell the tree. They are, however, not above selling the tree for fuel, in return for a consideration, provided the purchaser fells and removes the tree himself. The superstition is also not strong enough to secure the tree against wholesale lopping and which the cultivators resort to in autumn to diminish perching room for birds that feed on ears of corn. The wounds caused by this practice become the seat of fungi and probably make the axillary buds to develop into cupressiform rather than horizontal branches. This, coupled with the fact that Ramkati is found only on cultivated land, has led some observers to believe that it is only an abnormality. In and around cultivation in Rajputana, Ramkati is even more common. Thus there is no doubt that Ramkati has come to exist as a distinct variety. In Rajputana the wood of Ramkati is largely used in house construction, even in cases where ornamental carving is required. In Berar with the advance of knowledge a greater use will certainly be made of this tree than heretofore. Of all these three varieties Ramkati seems to need the greatest amount of cultivation of the soil and as a forest crop it may therefore be neglected. Telia is the more exacting of the two remaining varieties as to quality and depth of soil and moisture. It has also an aversion to localities where the soda efflorescence is very large. Thus it is that Telia exists and grows best close to streams while Kaora can thrive further away. The scattered situation, away from the Purna River, of the Babul bans in the Amraoti Division, and in the Murtizapur Taluk of the Akola Division, favours this selection and in consequence more Telia is found there than Kaora.

Associates.

Speaking of the species as a whole, the number of its associates, owing to its great light demanding nature, is very limited. For this reason it does not even admit of our growing a mixture of age classes in a Babul crop. Where it exists as scattered trees it will generally be found that this condition is satisfied, and when that is so, it grows with any species. Where it grows pure or nearly pure, especially in the Payanghat, the following are its usual associates :—

Murmati	...	...	...	*Acacia eburnea.*
Hingan	...	...	...	*Balanites Roxburghii.*
Yelatri	...	...	...	*Dichrostachys cinerea.*
Hiwar	...	...	...	*Acacia leucophlea.*
Soundar	...	...	...	*Prosopis spicigera.*
Pachran	...	...	...	*Capparis grandis.*
Ber	...	...	...	*Zizyphus vulgaris.*
Shindi	...	...	...	*Phœnix sylvestris.*
Nim	...	...	...	*Azadirachta indica.*

In a favourable locality the existence of these associates is not noticeable, but in unfavourable localities the associates become prominent. In areas where the yellow calcarious loam appears at the surface, Babul confines itself to the depressions on account of the deposits of silt or black soil and any or all of the associates save Shindi occupy the rising ground. Similarly in swampy localities Shindi predominates.

Seasons when new leaves, flowers and fruit appear.

In Berar Babul is never completely leafless, though in April and May it has very meagre foliage. Its new leaves appear early in June. It maintains its vegetative activity longer than many other species. Flowers from July onward throughout the rains, towards the end of which, about September, the fruit begins to develop. The pods are ripe by February and begin falling to the ground without dehiscing on the tree.

Germination and early life.

Babul seed has a hard testa and consequently its germination without some preparation is not always satisfactory. Much moisture in the soil is required to decompose the testa. The seed has been found to remain uninjured in the soil for fully three years, and to germinate well in the fourth monsoon, when a fire had passed over the area sown during the preceding hot weather (Kodad forests in the Akola Division). Long breaks in the rain before germination is complete are also likely to destroy the faculty of germination in the seed. In the Loni-Bhongaon Working Plan, therefore, sowing only when the monsoon has fairly burst is prescribed. From all the above it is evident that some method of forcing germination is necessary. The cheapest and the best method is to feed cattle, especially goats and sheep, on the pods and obtain the seed that has passed through them. Such seeds are less subject to attacks by weevils when they are stored.

The seedling develops a strong and fairly long tap root and gives rise to numerous lateral roots at the end of the first season. As the growth advances the difference between the top root and lateral roots as to strength, size and importance is lost. The root system therefore becomes compact and massive. For this reason the species requires the water-bearing stratum fairly close to the surface or soil sufficiently deep and hygroscopic to yield the required moisture.

It is popularly believed that Babul growth dries up streams, and some observers have been of opinion that Babul will convert marshy into dry land. This belief is, in some cases, the cause of the destruction of the tree on private land. It is, however remarkable that a large amount of water oozes out of the stumps of freshly felled Babul, which is seldom or never found in other trees in Berar.

Above ground the seedling develops spines one month after germinating which protect the seedling against all kinds of cattle except browsers. It displays its light demanding nature from the very commencement. Thus when it is hampered by grass and weed growth it remains fragile, but when freed by weeding or grazing it grows vigorously developing strong lateral branches which attain, in favourable localities, a height of about 4 feet in the first year. Though the main stem is always distinguishable, Babul often retains a bushy appearance for a long time. For this reason, it is necessary to grow Babul fairly dense to secure good height-growth. It does not seem to suffer (Telia more so than Kaora) in spite of its light demanding nature from the interlacing of the branches or crowns. Generally speaking a Babul crop attains a height from

12 feet to 15 feet in 10 years. Babul grows rapidly in height, attaining its maximum, which is from 20 to 30 feet, in 15 to 20 years; beyond which period lateral growth only continues in favourable localities even up to and beyond 40 years. Telia when allowed to grow on like this attains a height of even 40 feet.

Later life of Babul.

A radial growth of 5 rings to the inch has been recorded in the Loni-Bhongaon Working Plan. Evidently the ring countings have been made from more or less average stems. Trees on favourable situations, such as nala banks, have given an average of 2·3 rings to the inch. In exploiting a crop of Babul, however, there seems no use to wait longer than 25 years, but selected trees could be grown to a girth of 6 feet in 35 to 40 years on favourable situations. Of the three varieties, Ramkati grows fastest, next comes Telia, and last of all Kaora. Telia is the longest lived tree of the three.

Babul produces fertile seed at an early age, individuals hardly seven years old have been found to bear flower and fruit. It is fully fertile from 12 to 15 years. It does not coppice well, though in the early stages of its growth it is able to successfully replace an injured leader or to shoot up anew when the stem gets cut off altogether. In Berar the stools of old tree do not send up shoots at all. Those of trees not exceeding 2 feet in girth send up shoots but they only develop into bushes.

Reproduction.

The uses to which the Babul tree and its various parts are put to, are too numerous to be described in detail in this paper, which must, obviously, confine itself to enumerating only such as influence its silviculture. It is most useful to the cultivator in all stages of its life. In the earlier stages it yields him thorns for fences; when it reaches the sapling or pole stage it yields him poles and posts for his huts *(chappars)*, shafts for ploughs and hoes, wood for the frame work and legs of rough charpoys and so on; at a later stage agricultural implements are made out of it; when mature the wood becomes fit for beams and karies of "dabhas" (flat roofs), door choukats, cart wheels, &c., and lastly the cultivators' cattle feed considerably on the pods. As a timber Telia is greatly prized because of its wood being close-grained and more durable than either of the other two varieties and when grown, so as to form a canopy, it yields a fairly straight clean bole, 15 feet to 20 feet long. Such specimens may be met with in favourable localities of State Babul *bans*, in road-side strips, *khalwadis*, and so on. Telia seasons well, and storing for one year is considered to season it sufficiently for ordinary use. Kaora is, as a matter of necessity, used as timber in place of Telia where this is not available. Its wood is coarse and brittle, seasons badly, cracking a good deal during the process. These defects do not come in the way of its being used for agricultural implements. The prejudice against the use of Ramkati as timber has already been described.

Uses.

All the three varieties yield very valuable fuel, next only to coal. Babul fuel gives rise to deposits of salts on the inside of boilers, but this it does to a much smaller extent than other kinds of firewood. This drawback, however, is overlooked as at present the price compares favourably with coal. Hence there is a good demand for Babul wood for the ginning factories and cotton presses which exist in numbers in many parts of the country, the contractor getting 8 to 10 rupees a ton, according to the character of the cotton season, while his cost including what he pays to Government varies from 6 to 7 rupees a ton. The price of coal varies from Rs. 12 to Rs. 16 a ton. Branchwood, too thin for engine fuel, is cut up into billets about 2 feet long and sold to factories for lighting engines and as *chula* fuel in the larger towns. The price obtained for this small wood is Rs. 15 and more per ton.

The bark of the tree yields a strongly astringent decoction and is used largely in native medicines. It is also used for tanning purposes. The gum is said to be strengthening; it is fried, made up with sugar into a sweetmeat, and given to convalescents. Cattle feed on the pods, and they are largely used for tanning purposes.

Babul is subject to injuries from the very commencement of its life. A young Babul crop, growing with the branches interlaced, affords an ideal cover for rats, hares and deer, when the country all round is bare. The deep cracks in the black cotton soil is specially favourable for rats as was noticed in Bhongaon last year, where the antelope rat

Injuries to which the tree is liable.

(a species of Tatera), which lives in deep burrows, did a lot of damage to Babul seedlings. Rats gnaw the bark of the seedlings, cut off the shoots or devour the roots; hares cut off the shoots often down to the ground; deer browse the shoots. The injury begins when the seedlings are weeded in the rains, but becomes very noticeable when the harvest is over and nothing succulent or green is left in the fields. Fortunately, except where the root is destroyed, the seedlings usually recover though they may lose one or two year's growth. Rats, which are the most injurious of the above three animals, do not multiply to an alarming extent every year, or appear in large numbers in all Babul bans. Their existence largely depends on the character of the monsoon, heavy rain, however fitful it may be, being injurious to them. It has just been discovered that the antelope rat rears its young in nests built some two feet above ground in the interlaced branches of Babul thickets. This knowledge is of considerable help in keeping down their numbers. Ratin and other preparations which are said to create an infectious disease among rats have not yet been tried.

Full-grown insects (Imagos) of Batocera, Psiloptera and Cantharid beetles eat the leaves and the bark of the branches and twigs of young plants. This not only diminishes the vigour of the individuals but also seriously retards their upward growth. When the stems attain a diameter of about 1½ inch, a more serious injury comes to notice. The larvæ of the Batocera beetle tunnel through the wood. These tunnels are about half inch in diameter and frequently two such tunnels are found in one stem. The larvæ attack the stem at ground level and tunnel both ways but mostly upwards keeping open an air-hole through which the fibrous masses of wood tissue that has passed through the grub are thrown out. These excreta accumulate in masses several inches high on the ground close to the stem and betray the existence and activity of the enemy inside. The larvæ is found to beat work for quite seven months—December to the middle of July—when it pupates. Thus the damage, remembering the diameter of the stem attacked is severe, in spite of the extraordinary vegetative activity of the tree. Observations regarding the life-history of these beetles are being made, and a beginning has been made this year to capture and kill the full-grown insects which fly about singly and are easily caught. Among domestic animals, goats alone do serious injury, other animals do practically no harm, unless the number of cattle allowed to graze in the crop is very large and grazing is allowed too soon after the germination of the seed. Light grazing, as will be described later on, affords distinct advantages.

For thorns and fencing the saplings are hacked and the large trees lopped; for minor agricultural and household requirements reckless lopping is resorted to; for bark, the tree is nearly girdled and for fodder, the pods are beaten down with long sticks. Luckily, making gashes in the trunk to promote the exudation of gum is not practised.

Babul has a wonderful capacity for healing up wounds. Seedlings grown up on mounds have been found to fuse together into a single stem looking like coppice shoots grown on one stool. The tree does not fully recover from injuries received in its earlier life, but falls a victim to the ravages of fungi when it is nearing maturity.

Fomes pappianus is the fungus that does most damage to Babul in Berar. The sapwood remains uninjured by its attack and the tree therefore maintains an outwardly healthy appearance. The heartwood, however, is rendered more and more brittle as the fungus gains ground, till the tree is no longer able to withstand the force of ordinary wind and is blown down. In a badly attacked tree the wood crumbles to pieces like broken tiles. The Kaora and Ramkati varieties suffer more from the attack than Telia, because the wood in their case is less compact; Kaora with its massive crown more easily gives way to the action of wind. This fungus is known during the last two decades to attack Babul, but its ravages were only discovered to have attained serious dimensions in 1902-03 in Loni and Bhongaon reserves where large stretches of forests were seriously affected. With a view to utilizing such badly attacked portions before the rest, the order of felling in the Loni-Bhongaon Working Plan was changed for seven years—1903-04 to 1909-10. The prohibition in the working plan to do thinnings was observed to have rendered the crop in many places congested and languid. Thinnings were therefore at once taken in hand and the whole area was gone over in 1902-03 and 1903-04. During the progress of this operation most of the diseased trees, as a matter of course, were removed and the sporophores were

systematically removed and burnt. All these steps combined have now considerably reduced the seriousness of the pest.

The origin and propagation of this fungus has not yet been worked out. It is not certain whether it spreads by means of mycelia in the ground, or through wounds and defects in the trees. It attacks isolated trees, and trees in the midst of cultivation, just as much as it does trees growing in a canopy, with soil round about untouched. The remedial measures therefore were conducted on general lines calculated to purify the soil after felling; to increase the vigour of the tree, and to retard the dissemination of the spores by removing and destroying the sporophores. It is noteworthy that young and vigorous Babul is not attacked. Nearly all the trees attacked are those that have ceased to grow and have commenced to contract their crowns, be this the outcome of old age or of injuries.

Regeneration.

It has already been said that Babul does not lend itself to be grown as a crop of mixed ages. It is also characteristic of the tree that young growth does not come up when the old trees are standing on an area in any numbers. Hence we have always to be prepared to re-stock a blank area. On boundary strips and nala banks in the midst of cultivation, trees could only exist scattered. There, therefore, old trees could stand when younger ones equally scattered are preparing to replace them. These strips, however, afford ideal conditions for the natural regeneration of Babul. Cattle including goats and sheep, permitted to roam about wherever they please after the crops are harvested, bring in the seed in their droppings, as they feed on Babul pods, and this supply is supplemented by floods on nala banks..

The cattle devour all the available grass, trample and triturate other weeds and tear up the ground with their feet, so that the seed is at once brought into contact with the mineral soil. The seed, as it has passed through cattle or has been thoroughly soaked in the flood water, germinates easily in the rains. At the same time the fields get sown up for agricultural crops and the general roaming about of the cattle is stopped. The plough bullocks and milch cattle of the cultivator, however, are led into the fields and pastured on the strips. This limits the amount of grazing and serves to put down weed growth to an extent favourable for the healthy progress of Babul seeding, and for reducing to a minimum the cover for rats and hares, since what is not eaten by the animals is trampled down by them. To the Babul seedling itself little or no damage is done, thanks to its spines and its recuperative powers. This process is repeated year after year with the result that very often the cultivator considers Babul a nuisance, as it persists in his fields in spite of the rough treatment it receives at his hand—growth as already described, and in spite of some amount of goat-grazing, that cannot be avoided.

In Government waste lands other than State-forests (*khalwadis*, free grazing lands, *gothans*, &c.), where time is no consideration, Babul growth has originated in the above manner. In State-forests, successful re-stocking as soon after the felling as possible is of great importance. Trusting therefore to nature alone to do the re-stocking is not sufficient in these areas. Hence recourse must be had to one or more of the methods of artificial regeneration. In the Loni-Bhongaon Working Plan broadcast sowings are prescribed, on ground more or less prepared, by means of the felling and export operations, to receive the seed with subsequent closure to grazing for three years. It is also prescribed that should the first sowings fail, the ground should be ploughed up (probably strip sowings were intended) and sowings renewed the second year and thereafter till success is assured, extending the period of closure to grazing accordingly.

Systematic exploitation of the Bhongaon Babul forests was commenced in the year 1895-96 and the prescriptions of the working plan duly carried out, but expectations as to the complete re-stocking the exploited areas were not realized, for out of a total of 497 acres felled from 1895-96 to 1902-03, only 135 acres flanking the Mass nadi become fully stocked. The balance, the greater portion of which lies away from the Mass, had to be leased out for cultivation under the agri-sylvicutural method. This state of affairs could have been averted, had grazing of non-browsers been permitted, to the extent to which it obtains on the uncultivated strips in the midst of fields, as already described, but this unfortunately was not allowed.

The policy followed elsewhere was also similar. For instance in the Murtizapur Taluq alone some 390 acres of Babul forests were exploited in the eighties.

Broadcast sowings were made in these areas and grazing prohibited. Partly with the object of diminishing the risk of fires and partly on financial considerations the areas were, however, annually leased for grass cutting. The result of this was that even the few seedlings that came up got cut away along with grass. When this error was discovered grass cutting was at once stopped and systematic re-stocking operations were taken in hand, the salient feature of which was the admission of light grazing. Generally speaking no grazing was allowed during the monsoon in which the sowings were made, but from October onwards cattle, up to two head per acre, were allowed to be pastured on the areas. Goats and sheep of course were rigidly kept out. Owing to this change in the policy, the area noted above with the subsequent additions is now fully stocked with most promising growth.

Two photographs (Plates I) illustrate these results :

The first photograph represents the result of strip sowings in Nowsala forests, Survey No. 68. The area, which was completely bare, was sown up in 1893 rains and failures renewed every year up to 1897 rains. The crop now is over 20 feet high and thinnings were made for the first time last year.

The second represents the result of mound sowings in Khodad forests, Survey No. 89. The area which was dotted with young bushes was sown in 1892 rains and failures renewed in the 1893 rains. The crop is over 20 feet high and thinnings were made for the first time in 1904-05 and 1905-06.

If advantage is not taken of grazing to put down weed growth, it becomes necessary to weed round the seedlings for one or more years, as these cannot stand higher than grass and weeds. This is a slow and expensive work and can never be free from risk of fires. The labourers have to be paid higher wages than they get from agriculturists, as freeing thorny bushes from weeds is not very inviting work when employment is plentiful in fields all round the village.

In the Bhongaon forests weeding has been resorted to, to give the seedlings, that have come up successfully as a result of agri-sylvicultural sowings, the light they require. The cost has been on an average Rs. 2 per acre per annum, and the operation will probably have to be continued for three seasons, at the end of which grazing will probably be allowed. This expenditure of Rs. 6 an acre would have been avoided had light grazing been permitted.

When by either of the above described means sufficient freedom from weed growth is ensured for the seedlings, the following methods have given satisfactory results :—

(I) *Broadcast sowings.*—This succeeds on areas which flank small streams that flow through the area to be sown up. The cost would be trifling, about 4 annas an acre.

(II) *Mound sowings*—These are made in areas subject to floods or in swampy or water-logged situations. Low mounds 6 inches high and 2 feet in diameter in lines 8′ × 4′ have given good results. The cost has not exceeded Rs. 3 an acre.

(III) *Patch sowing.*—These are made in sowing up open places amidst young Babul growth or of other species that may be already existing where the plough cannot be worked. Patches 2′ × 1′ cleaned to a depth of 6 inches in lines 8′ × 4′ have given good results. The cost would not exceed Rs. 2-8-0 per acre.

(VI) *Strip sowings.*—This method is the one that has been largely adopted up to date. The strips are made at intervals of 10 feet by means of three confluent plough furrows ; each strip would therefore be about 2½′ broad. The cost has been from Rs. 2-8-0 to Rs. 2-12-0 an acre.

In the above four methods parking goats and sheep all over the area, before the first sowings are made, is recommended if possible. Where germination is not complete, those patches or mounds or lengths of strips that are blank should be raked up and re-sown in the following rains ; four annas an acre was found sufficient for this.

(V) *The agri-sylvicultural method.*—This method is of recent origin. It consists of raising any field crop for the first two years over the area to be sown and of sowing Babul in the third year with

cotton, three lines of cotton being put in between two consecutive lines of Babul. The latter therefore got a spacing of 7 feet. The Babul lines are weeded as thoroughly and as often as cotton.

This is the surest method of ensuring regeneration, and one that gives a good start to the seedlings, and minimizes the advent and multiplication of insects and fungi, in spite of the fact that the cotton crops often attract rats. As the coupes are sold with permission to cultivate the land for three years the prices paid in some localities to Government have increased by about 100 per cent. The advantages therefore more than counteract the loss of two years growth after the felling. On favourable situations, the Babul lines meet laterally in two seasons, the height of the lines in the first year being 4 feet. Elsewhere the lines would require three to four years to meet. It not infrequently happens owing to variations in soil or situation, or other accidental causes, the lines are not full or in average situations the intervals between the lines are not grown over in two seasons by the Babul seedlings. It is then advantageous to allow, wherever possible, cotton cultivation for another year on the condition, that only two rows of cotton are raised between the Babul lines; that the latter are not disturbed during the preparation of the soil for cotton sowings; that blank lengths in the Babul lines are raked up and re-sown and that the Babul lines are weeded. This plan materially checks weed growth and lessens the risk of fires. Cultivators, however, are not very willing to take up this second year cultivation, as working the hoe between the Babul lines is a tedious process. The thorny branches striking against their legs, the bullocks refuse to work. In any case as only selected areas could be treated in this manner, the leases for this mode of cultivation are given out for three years only.

The operation costs Government in the beginning nothing beyond supervision and perhaps assistance to collect the right kind, quality and quantity of the seed. The collection of seed is a difficult business, as the sowing is made in drills and as much as 15 seers to the acre is needed for the first sowings. For renewing of failures three seers per acre would be sufficient. When the three-year lease has expired a reward of not exceeding Rs. 2 an acre is paid for all areas fully stocked. This is an incentive to good work. Reducing the period of the lease to less than three seasons would not pay the lessees, as the cost of first preparing the soil is large (about 8 rupees an acre) and the crop in the first year is not reliable as the soil has not undergone sufficient aërating.

It is obvious that this method has its "raison d'etre" in localities where there is a demand for land for cultivation. Such demand exists in many parts of the Payanghat and the system is therefore coming into favour. In the Buldana Division alone the following areas have been satisfactorily treated under the above method:—

			Acres.
Bhongaon reserve	...	...	576
Other Babul bans	...	...	197

Plate II, figure 1, represents successful agri-sylvicultural sowings on an average area in Bhongaon coupe No 7. The growth is three seasons old and the lines have nearly closed laterally—note the weeding party is nearly hidden. Plate II, figure 2, shows agri-sylvicultural sowings two seasons old, two rows of cotton having been permitted to be grown between the Babul lines as these were found to be sufficiently stocked at the end of the first season.

Treatment.

The following extracts from the Sanctioned Works Plan of the Loni-Bhongaon Reserve and the Proposed Working Plan for the forests of the Amraoti Division give the opinion of Berar Forest Officers on the treatment of Babul woods in 1902:—

LONI-BHONGAON PLAN.

"A careful examination of the Babul growth in the Purna valley has shown that the tree begins to deteriorate and branches die off after the tree has attained a diameter of nine inches while fuel of that size is also most saleable. From the results of ring counting on 44 stumps in Loni (see Appendix IV) it has been found that the average annual radial growth is 19 inches, or say five rings per inch of radius, and this tends to show that the Purna Babul takes about 25 years to attain a girth of 30 inches. The figures given above might justify the adoption of 25 years as the period taken to attain maturity, but it is hoped better management as to protection, &c., will render it possible to lengthen the healthy life of the tree, while it is also well to allow a margin for safety as to complete reproduction, so that 30 years has been adopted as the rotation for the first period, which, owing to the existence of blanks and the irregular distribution of age classes,

must be looked on as partly reconstructive, partly transitional. The fact that we are trying to introduce the longer lived Telia in lieu of Kaora, a short-lived tree, is another argument in favour of adopting 30 years for re-stocking the forest."

PROPOSED AMRAOTI PLAN.

"The object to be striven for here is the largest possible yield, since fuel is the main produce required, and along with the fuel there will always be obtained a certain proportion of timber. Accordingly a long rotation is to be avoided. We have no exact data for determining the best rotation to adopt, but the consensus of all Berar Forest Officers favours a period of 25 years, by which time Babul grown in canopied crops will have attained its maximum height, and the individual stems will be from two to four feet in girth. If larger timber is required, a few select stems can be spared at the time of exploitation along the border of the coupe to grow on for another rotation."

Experience has shown that an allowance of three years must be made to successfully re-stock areas. This would weigh in favour of the adoption of a 30 years rotation, on the other hand it has been shown that the tree becomes liable after an age of about 20 years to serious damage from fungi. Thus it seems best to adopt a rotation of 25 years, reserving in favourable places select specimens of Telia, if available, to grow to large timber, till the end of the next rotation. The number of these reserves should be very limited and the trees should stand very far apart. About four trees to an acre would be the utmost, and there should be no hesitation in keeping within this limit, as even when the whole crop is allowed to grow on, the conspicuously big trees would not exceed that number.

Modified as above, clear fellings would be the method of treatment most suited for Babul. When Babul is grown in suitable localities in mixed forests, or round the waterspread of tanks, the soil generally does not exceed three feet in depth and the sub-soil is nearly always impermeable. In such cases trees begin to die at an earlier age. A shorter rotation, 20 years, would be advisable in these cases.

Recent experience has shown that one or two periodical thinnings are necessary for the healthy development of Babul. These operations have been carried out to a considerable extent in the Amraoti and Akola Divisions in the interest of the young Babul crop raised during the past decade and a half. In the Murtizapur Taluq alone 391 acres have been thinned during the last three years. These areas represented a growth of 10 to 13 years after the sowings were completed, and as an allowance of two to three years after the felling has to be made for completing the re-stocking operations, it is safe to conclude that the first thinning is best made in the 15th year after felling. This operation would be moderately severe as the crop does not cease upward growth till some four or five years afterwards, so that the second and a severe thinning in the 20th year after the felling would have for its object the promotion of only lateral growth.

Financial aspect of Babul cultivation and conclusion.

Before thinnings in Babul bans were introduced the revenue from Babul crops varied from Rs. 25 to Rs. 60 an acre. As what is lost in the thinnings is likely to be gained in the shape of improved growth by the time the final fellings become due, it seems quite safe to look forward for an average value of Rs. 40 an acre from final fellings.

The thinnings done in the "*bans*" of the Mutizapur Taluq were the first thinnings as already described. Those done in the Bhongaon forests of the Buldana Division were made in the old growth and partook more of the nature of second thinnings. The receipts in both cases were about equal, *viz.*, Rs. 7-3-0 an acre, but as no thinnings had been previously made in Bhongaon it is probable that more than Rs. 5 an acre could not be expected in the second thinning. These operations having to be done always departmentally, the cost was Rs. 4 an acre in the former (the first thinning) and Rs. 1-8-0 an acre in the latter (second thinning) case.

Summing up, therefore, the receipts and expenditure in rearing a Babul crop would be per acre at the end of a rotation—

Receipts.

	Rs.	a.	p.
First thinnings	7	0	0
Second thinnings	5	0	0
Final fellings	40	0	0
Grazing and other sources Re. 1 per annum ...	25	0	0
Total ...	77	0	0

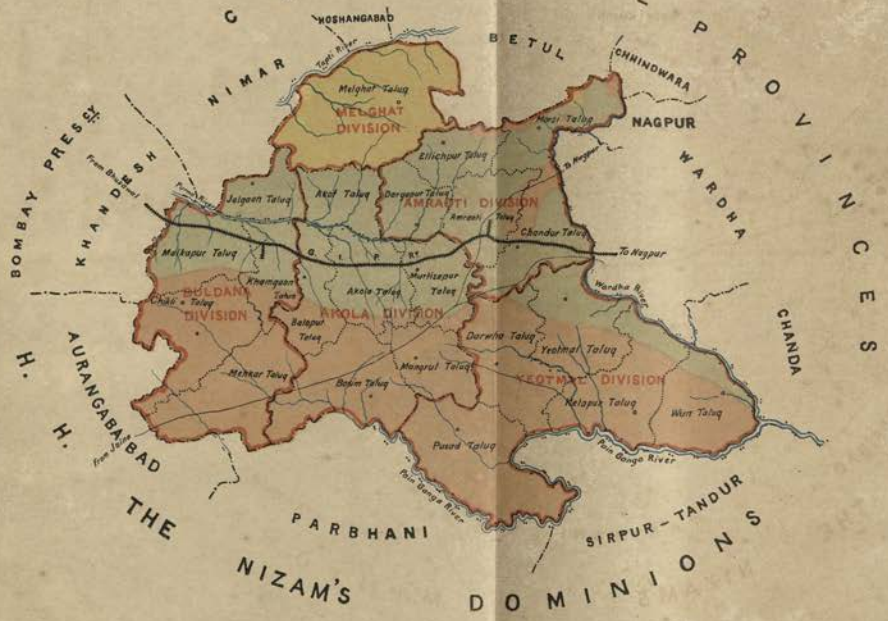
Expenditure.

	Rs.	a.	p.
Initial sowings	3	0	0
Subsequent renewal of failures	1	0	0
Cost of first thinning	4	0	0
Cost of second thinning	1	8	0
Miscellaneous charges such as remedying natural injuries, &c., one anna per acre per annum	2	0	0
Total ...	11	8	0
Profit ...	65	8	0

If grazing is not permitted for the first three years but weeding resorted to the cost would increase by Rs. 6 per acre—even then the margin of profit is large. The net return to Government would vary from Rs. 2-6-0 to Rs. 2-10-0 per acre per annum, a rate which compares very favourably with the rate of land assessment in the black soil country and which accords Babul a high place among forest crops. With the greater cultural attention now paid to Babul crops it is probable the future annual yield of the tree from State Babul *bans* would be about one ton or 40 cubic feet per acre or 624,000 cubic feet solid for the Province which would represent a revenue of Rs. 45,000 per annum.

The consumption of Babul wood, however, judging from the manner in which the tree is being cut down, is enormous, probably twice or thrice as much as could be obtained from the State-forests. Hence it is time that cultivators and others assume a friendly attitude towards the tree. The requirements of the tree, the soil and situation being suitable, are so simple that they should experience no difficulty in adhering to the rule of felling a tree only when they have grown another on their land to take its place, while the Forest Department should make plantations wherever the ground in the State-forests is suitable.

MAP OF BERAR CIRCLE
SHOWING DISTRIBUTION OF BABUL
SCALE 32 MILES TO 1 INCH



REFERENCES.

- District Boundary { Natural / Artificial
- Taluq ... do.
- Railway Line
- Roads
- Rivers
- Tract without Babul
- Tract where Babul is the most common tree
- Tract where Babul exists as a scattered tree or in small patches.

S. Shrinivaslu Nayadu.
Extra Assistant Conservator of Forests
Buldana Division, Berar Circle.

By: M. Pocket. Draftsman. Dated 21-1-29

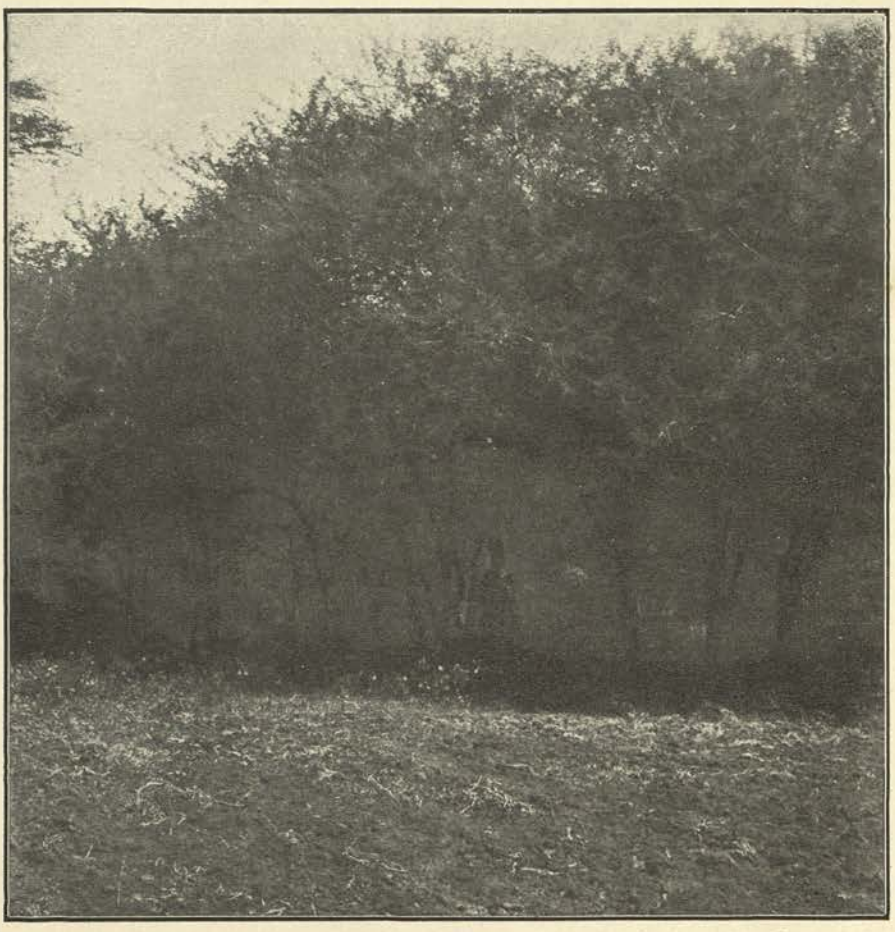
Reg. No. 1119 E. 06-7-30.

PLATE 1.

Figure 1.

The Nawsala Babul wood regenerated by method of strip sowings. Area which was a blank was sown in the rains of 1893 and failures resown annually up to 1897. The crop is now over 20 feet high and was thinned for the first time in 1907.

Figure 2.



Engraved & printed by Survey of India Offices, Calcutta. 1909.

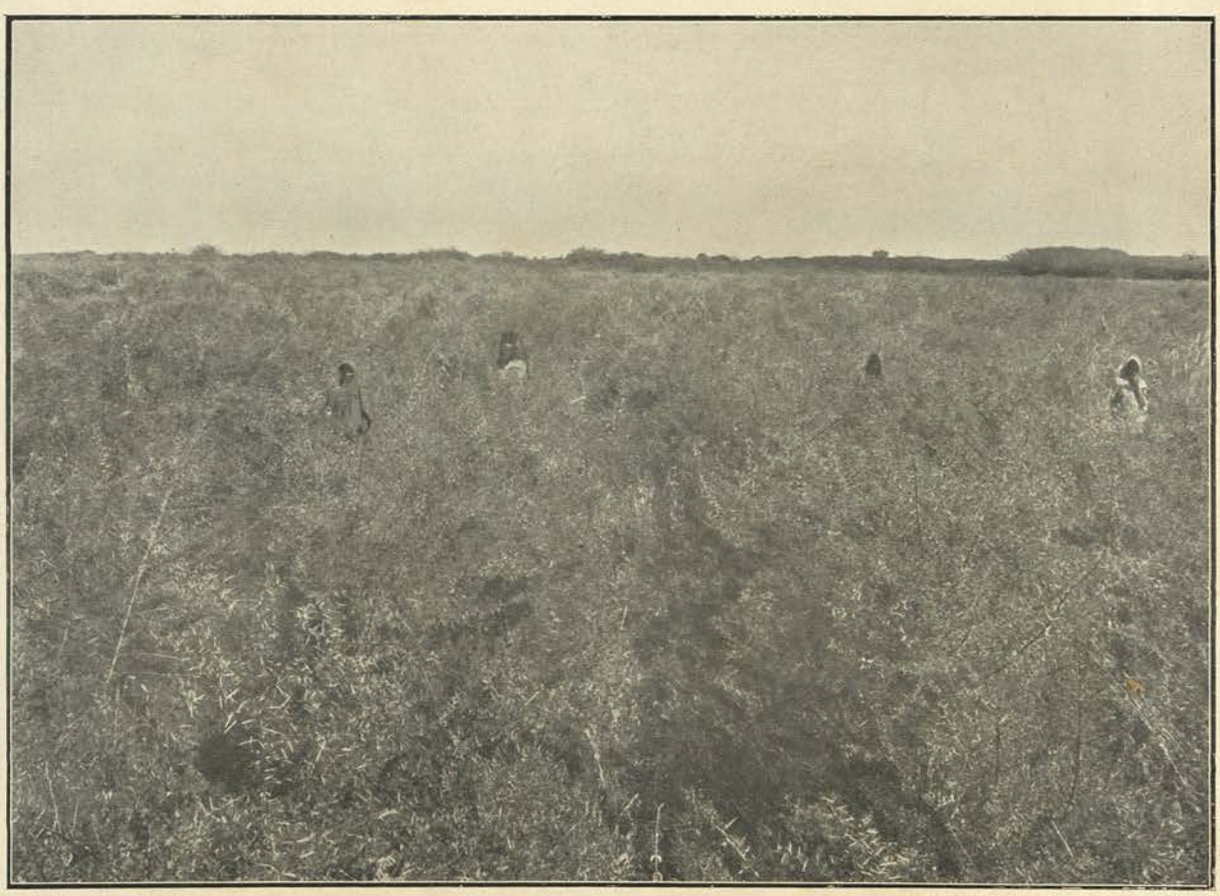
The Khodad Babul wood resulting from sowings on mounds. The area was sown in the rains of 1892 and vacancies filled in the rains of 1893. The crop is now over 20 feet high. It was thinned for the first time in 1904-05 and 1905-06.

PLATE 2.

Figure 1.

An area regenerated by the system of raising forest with field crops in the Bhongaon State Forest. The Babul seedlings are 16 months old. Two rows of cotton are grown between the rows of Babul seedlings which are 6 feet apart.

Figure 2.



Engraved & printed by Survey of India Offices, Calcutta, 1909.

An average area sown up with Babul in the Bhongaon State Forest. The Babul seedlings are 28 months old. The area has to be weeded as there is no room for the cultivation of cotton between the rows of Babul seedlings which are 6 feet apart.

DISCUSSION ON MR. SHRINIVASALU'S PAPER.

Mr. Shrinivasalu in opening the discussion drew the attention of the members to a map he had prepared showing the distribution of Babul in Berar and invited discussion as to the varieties of Babul; the desirability of growing Babul as a mixed crop; the advantages and disadvantages of allowing the grazing of cattle in Babul woods; and the proper sylvicultural treatment of Babul, including the regeneration, the maintenance of a proper density in the crop.

Mr. Maitland-Kirwan described the growth and habit of Babul in Sindh as it differs materially from that described by Mr. Shrinivasalu in his paper. In Sindh it appears that the presence of Babul forests depend upon either inundations of the river Indus, or upon the artificial flooding of land near that river. Areas are regenerated by broadcast sowings of seed that has passed through cattle about the middle of September, when the inundations are subsiding. In suitable localities, excellent results are obtained from this method, although frost kills a number of the seedlings. The damage by frost is accentuated by the silvicultural system adopted—clear felling. In less favourable localities where the soil is poor, regeneration by sowing is not so good, the seedlings suffer more from frost and are injured by a dense growth of grass. *Kandi* (Prosopis spicifera) appears in the crop and in still less favourable localities Babul is entirely replaced by this species. During the last three or four years, on higher-lying land, which cannot be irrigated from natural channels, a Persian wheel has been erected on the bank of the nearest canal, water lifted on to the land and led all over it by means of a net work of small water channels. Land of this description is given out for cultivation on three years' leases on the following conditions. The first year the cultivator can grow a cereal crop such as *Bajra* or cotton and must sow Babul broadcast over the area and also along all the small water channels they make for irrigating their crops. The second year they plough up all blanks and sow cotton and cereals (they must sow at least 50 per cent of cotton) on the area, and are required to water the whole area leased to them and to sow more Babul seed in the blanks which remain. In the third year they are not allowed to sow any field crop, but may collect the cotton from the crop sown during the second year. They have also to water the whole area. The cultivators pay rent the first two years at the current rate of assessment in the district for the land leased to them, but pay no rent the third year. This system is reported to be very successful where conditions are favourable; the failures that have occurred being attributable to the poorness of the soil and unfavourable (short) rains. In Sindh areas under regeneration by sowing are closed to grazing animals for five years, and to browsing animals for ten and this system Mr. Maitland-Kirwan considers good, as in the most favourable localities the growth of grass is inconsiderable. In the localities less suitable to Babul, *i. e.*, those which are not so thoroughly inundated, Mr. Kirwan recommends that some sort of shelter wood should be kept to protect the seedlings from frost and advocates that, where the grass interferes with the development of the seedling, light grazing should be allowed a few months after the seed is sown.

The question of the varieties of Babul was then considered and it was generally admitted that the two principal varieties were *Telia*, (called *Godi* in Bombay) and *Kaora*, (the *Vedi* of the Bombay Presidency) and that the third variety, *Ramkati*, was much less common and of little importance. *Telia* and *Kaora* appear to be quite distinct varieties, with constant characteristics, such as the bark, branch system, shape of pods, and locality. The *Telia* variety only flourishes on black cotton soil, grows much more vigorously, attains a much larger size and reaches its greatest dimensions along the banks of sluggish streams which are inundated for a short time during the rainy season. The growth of this variety falls off very rapidly with the distance from the bank of the stream. Mr. Shrinivasalu has pointed out that the lands where *Telia* grow best is saline and suggest that the vigorous growth is probably due to the presence of the salts in the soil.

Kaora grows on poor dry rocky soil, the result of the decomposition of trap. Its growth is much slower and its ultimate size is much less than that

of *Telia*. So far as our experience goes at present *Telia* will not grow on the poor soil on which *Kaora* is found. No experiments have yet been made to determine if the seed of the *Kaora* variety would maintain its characteristics if sown in black cotton soil. As it was evident that the question of the varieties of Babul had not been thoroughly enquired into, it was resolved (*Resolution No.* 30) that the President of the Forest Research Institute might be asked to allow the Imperial Forest Botanist to take up this question.

The possibility of growing Babul as a mixed crop was then considered. Mr. Shrinivasalu pointed out that so far as black cotton soil in Berar was concerned, it was not possible to grow mixed Babul woods as practically no other tree would grow on that soil. *Kaora* could be grown with the species noted on page 219 of these proceedings, but as they were all of very little value, it was doubtful whether the *Kaora* variety should be grown mixed, if the soil allowed of its being grown pure. Mr. Fisher said that in Bombay Babul was usually grown pure, and that the only species which might be grown with it was *Shisham* (Dalbergia latifolia). In Sindh Mr. Maitland-Kirwan said Babul grew pure in localities which were well suited to it and that in those it would not be practicable or advisable to introduce other species. The general conclusion arrived at was, that where the soil and factors of the locality were suitable, it was impracticable to grow anything but pure Babul forests, and that so far as our experience goes at present, there was no objection to doing so.

The Conference then took up the question of the advantages and disadvantages of allowing closing Babul woods to grazing, especially during the first few years of their life.

Experience in Berar shows that the closing of areas shown with Babul to grazing for the first few years of their life was most harmful, in that it allowed a strong growth of grass and weeds to spring up, which killed nearly all the seedlings, while those which survived were very unhealthy. On the other hand Babul sprang up everywhere on waste land, especially near the banks of small streams which were heavily grazed over, and persisted year after year in cultivated fields in spite of the efforts of the cultivator to eradicate them. Mr. Newman stated that in Kandesh it was the custom to fence areas sown with Babul to keep out cattle, the sowings never very unsuccessful and in his opinion would remain so unless light grazing was allowed. Mr. Lachman Das said that in Jodhpur the grazing of cows and bullocks was allowed in areas sown from the beginning and that the result was that the areas were fully stocked with seedlings. In Sindh Mr. Maitland-Kirwan said that areas sown were closed to grazing for five years after the seed was sown. It must be remembered that here Babul is sown on land which is inundated annually, that the weed growth is consequently very slight, and that the conditions consequently differ materially from those in the Central Provinces and Central India. *Resolution No.* 32 was then framed and passed. The proper silvicultural treatment was then discussed. It was unanimously agreed (*Resolution No.* 32) that the system best suited to Babul was that of clear felling and subsequent re-stocking of the area by artificial means. The best method of attaining this end was then discussed. Various methods (see Mr. Shrinivasalu's paper, page 224) have been tried with varying success which seems to point to the fact, that it is at present impossible to lay down any hard-and-fast rule with regard to the actual means of bringing the Babul seedlings on to any given area. The success of the sowings seem to depend very largely upon the amount of supervision which is given to them by the Forest staff. There are no proper records of the result of the various methods of sowing Babul which have been tried and it was therefore resolved (*Resolution No.* 33) that experiments should be made in Berar to decide the advantages and disadvantages of the several methods of sowing Babul. It was generally admitted that Babul seed which had passed through goats had a much higher germinating power than seed which had not been eaten by animals. This point should also be definitely decided by direct experiment.

The question of whether Babul plantations should be cleaned and thinned, and the proper density of Babul woods in order to give the greatest yield was then considered. It was considered that it would be necessary to define what was to be understood by cleanings and thinnings, this was first done (*see Resolution No.* 34). From the discussion which followed it was clear that two very different views were held on the subject of the proper treatment of Babul. Rai Bahadur

Mansukh Rai and Mr. Shrinivasalu, both officers who have had a long practical experience of Babul, held very strongly, that after a certain age the principal growth in the volume of Babul took place in the branch system and not in the main stem ; that it was necessary to grow Babul in very open woods and for the last third of the rotation to completely isolate the crowns. Messrs. Rogers and Fisher held that no case had been made out for the exceptional treatment of Babul and that the ordinary principles of cleanings and thinnings suitable for light demanding trees should be applied to Babul woods. It was consequently resolved that experiments should be made in Berar (*Resolution No.* 34) to determine the correct density for Babul woods and the manner in which the thinnings should be made to obtain the greatest yield.

Rai Bahadur Mansukh Rai moved that an investigation should be undertaken to ascertain if there was any truth in the very widespread native belief that Babul trees drew out a great deal of moisture from the soil. This belief had led to the cutting down of large numbers of Babul woods, in order to increase the amount of moisture in the soil in localities where the rainfall was small. He did not believe there was any truth in this native belief, but felt that the question should be scientifically considered in the interests of the preservation of Babul outside Government forests. The meeting passed *Resolution No.* 36 and then rose for the day.

ERRATA ET CORRIGENDA.

Proceedings of Forest Conference held at Nagpur on 23rd November to 1st December 1908.

Page 128.—*Lines* 15 *and* 16 :—

For " Shisham " (Dalbergia latifolia) *read* "Nim" (Melia indica).

Govt. Press, Nagpur :—No. 1743, For.—26-11-10—300.

RESOLUTIONS PASSED ON MR. SHRINIVASALU'S PAPER.

Resolution No. 30.—That an investigation into the different varieties of Babul is desirable, particularly as regards their respective sylvicultural requirements, and that the President of the Forest Research Institute be asked to allow the Imperial Forest Botanist to take up this question from a botanical point of view.

Resolution No. 31.—That this Conference is of opinion that in pure Babul woods under regeneration it is highly desirable, and in some cases imperative, to allow the grazing of cows and bullocks only, in limited numbers, where grass and weeds occur, and that grazing may usually be allowed during the first year; that grass-cutting has been tried as an alternative to grazing and has been found to be positively injurious; and that it is probable that in all cases closing to grazing cows and bullocks is unnecessary.

Resolution No. 32.—That clear felling and subsequent re-stocking is the silvicultural system which appears to be best suited to Babul, and that for the present investigations be confined to determining the best method or methods of getting a new crop of Babul seedlings on to the ground under this system.

Resolution No. 33.—That investigations be made in Berar with a view to determining the comparative advantages of the recognized methods of raising Babul, as regards initial cost and the volume of the resulting crop.

Resolution No. 34.—That the subject of cleaning or thinning in Babul woods requires further investigation.

By *thinning* is understood an operation for the improvement of the dominant trees by giving them more growing space. The removal of all other stems on the area would be included in the term *cleaning*.

Resolution No. 35.—That an investigation should be made in order to determine whether the Babul woods cause streams to dry up and whether the cultivation of Babul materially decreases the degree of moisture in the soil.

SECTION VIII

MINUTES OF THE FINAL MEETING.

MINUTES OF THE FINAL MEETING.

At the final meeting, which the Chief Commissioner, the Hon'ble Mr. Craddock, honoured with his presence, the resolutions framed during the sessions of the Conference were read, put to the meeting and passed. *Resolution No.* 36 expressing the unanimous opinion of the members of the Conference as to the great benefits, both direct and indirect, derived from the present Conference was framed and passed. Mr. Craddock then addressed the meeting and spoke very strongly in favour of Conferences, provided that, as in the present instance, the meetings were limited to one of three hours' duration daily. He pointed out that long and numerous meetings were a mistake, as it was impossible for the members to maintain an interest in the points under discussion and said that much more useful work was done if short meetings, during which every one could take a lively interest in the proceedings, were held. Mr. Craddock then drew attention to the value of laying down programmes for research work, in ensuring that the investigations started were not lost sight of and that definite results were obtained from them. In the past, he continued, investigations had no doubt been made from time to time by Forest Officers, but that owing to want of method, or continuity of action very little information of value had been placed on record. The Chief Commissioner then drew special attention to the admittedly excessive grazing in Berar and asked if experiments could not be made as to the possibility of inducing forest villagers to grow fodder crops instead of cotton or food-grains. These experiments should be conducted by Forest Officers, but he said the Agricultural Department would, he felt sure, help Forest Officers in the selection of the fodder crops which should be tried.

The question of fixing the place and date of meeting was then considered and it was agreed that as the arrangements for the present Conference were so satisfactory that another Conference should be held in Nagpur in October 1909, if possible. Subjects for papers were then discussed and Mr. Craddock drew attention to the increasing difficulties of getting supplies of Mahua flowers (*Bassia latifolia*) for the Central Distilleries, and to the diminution of the number of Mahua trees in the Central Provinces and recommended that the distribution, artificial and natural reproduction, existing supplies of Mahua trees and existing methods of harvesting the flowers should be one of the subjects to be discussed at the next meeting of the Conference.

The following subjects were suggested by other members of the Conference:—

(1) The reduction of office work.
(2) The importance of forests to the development of agriculture and industries in the Central Provinces.
(3) System of fire-protection at present in force in the Central Provinces.
(4) Preservation of game in the Central Provinces.
(5) The timber resources of the Central Provinces.
(6) Improvement of the existing methods of the utilization of forest produce.
(7) Distribution and varieties of *Thikari* grass (Andropogon martini, *Stapf*) and distillation of Russa oil.
(8) The economical utilization of minor produce in the Central Provinces with special reference to *Harra* (the fruit of Terminalia chebula).
(8) The distribution of sal in the Central Provinces; present system of treatment and proposals for its working in the future.

The meeting ended with the passing of the subjoined resolution.

Resolution No. 36.—That the members of this Conference desire to place on record their appreciation of the benefits derived from it, in enabling officers of these and other Provinces to exchange opinions on forest subjects of practical importance, and to record the results of their discussions for the information of their colleagues throughout India, and that the Local Administration should be approached with a view to sanctioning the holding of further Conferences at stated intervals and the printing and circulation of the papers read at, and the proceedings of this Conference.

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